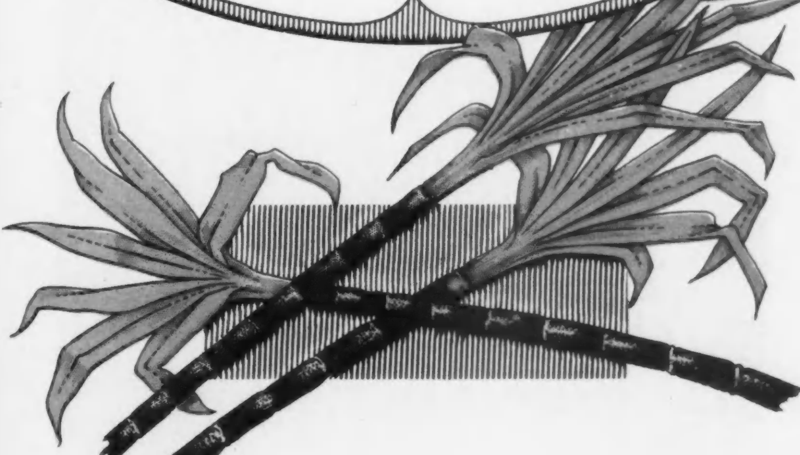
DEPARTMENT OF AGRICULTURE AND STOCK.

The CANE GROWERS' QUARTERLY BULLETIN

ISSUED BY

BUREAU OF SUGAR EXPERIMENT STATIONS

BRISBANE, QUEENSLAND.



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GUMMING DISEASE AT MULGRAVE

BUREAU OF SUGAR EXPERIMENT STATIONS
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ISSUED BY DIRECTION OF THE
HON. F. W. BULCOCK, MINISTER
FOR AGRICULTURE AND STOCK

1 APRIL, 1937

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—Bulletin—

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Mitscherlich Pot Tests.

By H. W. KERR and E. J. BARKE.

Introduction.

THE complex relationship between soil plantfoods and crop growth is fully recognised; and it is the difficult problem of the agriculturist to determine whether any deficiency of soil nutrients enters as a factor limiting crop growth. This is a problem of major importance in the cane areas of Queensland, where the soils are generally highly leached, and there exists a constant demand for artificial manures to maintain the productivity of the land. It has also been emphasised that the most reliable method for determining the existence of such deficiencies is that of field trial, in which cane yields are determined when certain plantfoods are withheld or supplied in the form of fertilizer. Given an adequately planned, carefully laid out experiment, results will be obtained which are directly applicable to the area concerned, under the climatic conditions experienced.

The most serious objection to the method is its tedious and laborious character. In any year, the number of field trials which an officer is capable of setting out and supervising is decidedly limited, and a period of many years must elapse before the data available can be regarded as in any way complete. There exists the further limitation that the results from a given trial area are specific for that area only, and to translate the results to contiguous farms is accompanied by a degree of uncertainty. In practice we find that this may be done, in general, with a measure of confidence; but there are occasions where the past fertilizer history of adjacent farms is so widely different, that soils which were originally very similar in character, now behave quite differently towards a given fertilizer mixture.

With a view to simplifying the work, and increasing the scope of fertility investigations, attempts have been made at various times to devise rapid alternative methods of determining plantfood deficiencies. These methods may be divided into two main classes:—(1) chemical tests, and (2) pot tests. It should be stressed that the reliability of such methods can only be established by a series of results obtained therefrom in comparison with actual field trial data obtained from the soil in question. The measure of success which we have gained with chemical tests for the determination of available soil phosphates, warrants the wide adoption of this method for Queensland conditions. Our results with chemical

tests for available potash have, however, left us indefinite; and we are anxious to acquire a reliable and simple test, by which we may determine, with a high degree of certainty, the need for potash manuring.

We have therefore turned our attention to the pot test method, which was introduced to Hawaii in recent years, and for which it is claimed that consistent and reliable results are obtained. It is the purpose of this paper to outline the principles underlying the method, and to illustrate the procedure with data obtained in preliminary tests, carried out during the past season at Meringa.

Mitscherlich's Method.

The pot test method devised by Mitscherlich, in Germany, has now become very widely employed in that country. It consists essentially of filling a series of pots with a representative sample of the soil in question, and adding to each pot in turn a pre-determined amount of material which will supply the desired plantfoods. Some pots receive a complete fertilizer mixture, while for others, one nutrient is omitted, or the proportions of each are varied. The pots are sown with oats, and watered in a regular manner, to maintain optimum growth conditions. When the crop has matured it is harvested, dried, and weighed. The relative increases in yield are then employed in calculating the proportion of available phosphate, potash and nitrogen in the soil, and from these figures, one may deduce the proportions of each constituent which could be expected to eliminate any deficiencies under field conditions.

The method is based on a "law" claimed to have been established by Mitscherlich, as the result of an experimental study of single factors on the growth of plants, under controlled conditions. It is really an extension of Liebig's Law of the Minimum, which states that the productivity of a soil depends on the magnitude of that particular growth factor which is present in least amount. Mitscherlich goes further and states mathematically that the magnitude of the increase in yield produced by a given increase in the *limiting growth factor*, is proportional to the decrement from the maximum yield which can be obtained by increasing that particular factor. An example may make this clear. Suppose a field, when heavily manured with a complete fertilizer, yields 60 tons of cane per acre; suppose we should find that, if the nitrogen be entirely omitted, the crop is reduced to 30 tons of cane per acre; that is, 30 tons less than the maximum. Now let us apply sufficient nitrogen to produce a 45-ton crop, that is, half-way towards the maximum, and suppose that this is given by an application of 2 cwt. of sulphate of ammonia. The yield is still 15 tons below the maximum, and according to Mitscherlich, further 2 cwt. of sulphate of ammonia will now raise the yield by one-half of the difference between 45 tons and the maximum, 60 tons, or in this case, to 52½ tons per acre. Further 2 cwt. of sulphate of ammonia will give a yield increase of ½ (60—52½) or 3¾ tons, giving 56¼ tons of cane per acre. The accompanying graph (Fig. 36) shows this theoretical relationship.

The same concept is also applicable to phosphate and potash and, of course, soil moisture supply, temperature, sunlight, and all other factors influencing yield.

Experiments have borne out, in a general way, the postulates of Mitscherlich; and the yield curves obtained for successive increments of plantfood bear a resemblance to the theoretical, though they diverge from it by greater or less amounts.

Technique Employed.

A description of the technique laid down for the pot trials will serve to illustrate the method by which the necessary information is acquired. The soil under examination is sampled to a depth of 10 inches in the field. The value of the sub-soil in crop nutrition is thus ignored in the pot work, but Mitscherlich makes allowance for this influence, by multiplying the amounts of available plantfoods as determined, by an appropriate factor. This assumes, of course, that the manurial requirements of all plants in a particular soil are identical; a point which is open to severe criticism.

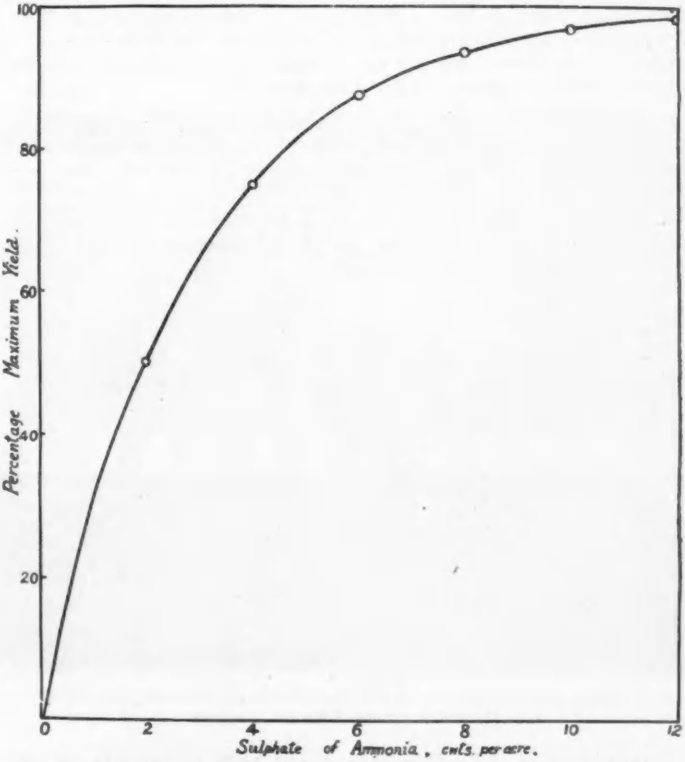


Fig. 36.—Illustrating the theoretical yield increment curve on which Mitscherlich's tests are based.

Mitscherlich employs oats as his "indicator" plant. This is not a suitable plant for the tropics, and extensive trials have been made to obtain a satisfactory alternative crop. Most of the work carried out in Hawaii, to date, has been done with Sudan grass, though attention is now being devoted to *Panicum muticum,* which it is claimed overcomes certain drawbacks associated with Sudan grass.

The pot employed is a cylindrical vessel, 8 inches in diameter and 8 inches deep, with a drainage hole in the bottom. It rests on a shallow

saucer, 11 inches in diameter and 2½ inches deep, which retains any drainage from the pot. A wire frame is provided to support the growing plants (*see* Figs. 37 and 38).

Generally 10 pots are employed for each trial, but with certain soils, it was found in Hawaii that excessive applications of phosphate were desirable in some of the pots. They have therefore added further 2 pots, making a total of 12 in the trial. This method has been adopted in the preliminary work in Queensland, and will therefore be described. Three pots are filled with soil to which has been added a complete (NPK) manure; three pots with soil to which nitrogen and phosphate have been added (NP); two with soil which has been treated with nitrogen and potash (NK). Three of the remaining four pots receive soil which has been treated with a "complete" mixture, but in which a variation has been made in the amount of phosphate; and one pot receives soil with phosphate and potash only (PK).

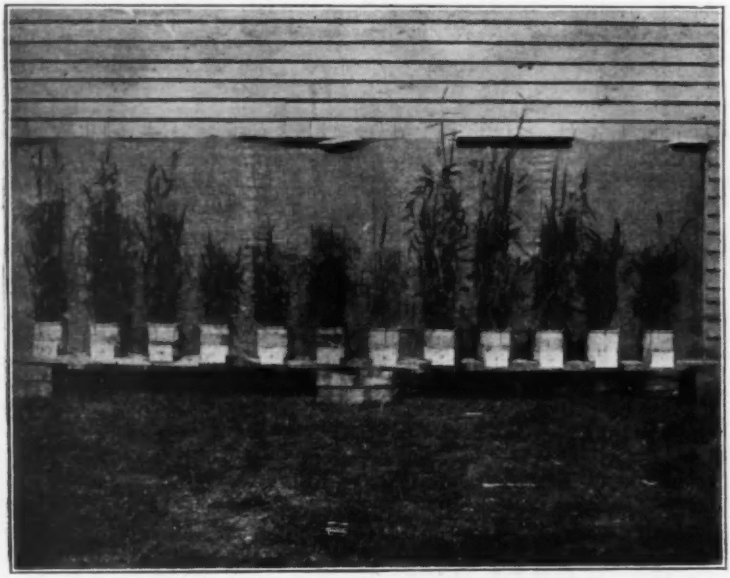


Fig. 37.—Illustrating the crop growth in the individual pots just prior to harvesting. Indicator plant—*Panicum muticum*.

The mixing of the soil is carried out very thoroughly, so that all pots and treatments receive identically similar samples. The plant-foods are added in the form of solutions in water; the substances used are nitrate of soda (N), superphosphate (P) and sulphate of potash (K).

Where Sudan grass is employed as the indicator plant, 70 seeds are planted in each pot: this is done with the assistance of a marking board, containing 35 equally spaced holes, and 2 seeds are dropped in each. They are thinned to leave 35 seedlings, when the plants have reached the second leaf stage. In our experiments, *Panicum muticum* was used; stem sections were kept in moist sand until the buds and roots germinated, and 25 were then transplanted to each pot. They were not affected by transplanting and gave remarkably even growth.

During the first two weeks, the soil moisture in the pots is kept at approximately 60 per cent. of maximum field capacity. Thereafter, the pots are liberally watered, and the drainage from the previous application is added to the soil before watering again.

The crops are harvested when the "complete fertilizer" pots are mature. With Sudan grass, this requires about two months: with panicum grass, the crops grown at Meringa from September to December failed to mature, due probably to the excessive temperatures recorded in the glass-house. Crops grown early in the spring matured satisfactorily. At harvest, the plants are cut off at soil level, and the yield from each pot placed in its individual bag. The bags are dried in an oven until they reach constant weight.

The computations are made from the results of these weighings. The average yield of the "complete fertilizer" pots is taken as the maximum yield, or 100 per cent., and all other yields are calculated percentagely in terms of this figure. By reference to tables prepared by Mitscherlich, it is then possible to compute the number of pounds of each nutrient present in an acre-foot of soil.

Calculation of Results.

To illustrate the manner in which this is carried out, we will consider the yields of panicum grass on soil from the plot trial of Messrs. S. J. Page and Son's farm, Edmonton, and carried out at Meringa.

Treatments and Yields.

Pot No.	Treatment.	Yield.	Average Yield per Pot.	Yield as per cent. of Maximum.
		gms.	gms.	%
1	N K	50·1	51·2	49·4
2	N K	52·2		
3	N 1P K	89·6	89·6	85·4
4	N 6P K	102·3	103·7	**100**
5	N 6P K	105·1		
6	P K	32·5	32·5	31·3
7	N 2P	56·6	56·0	54·0
8	N 2P	59·0		
9	N 2P	52·4		
10	N 2P K	77·6	78·9	75·1
11	N 2P K	78·5		
12	N 2P K	80·6		

Special tables have been prepared by the Hawaiian workers, based on their results with Sudan grass, and these tables have been employed by us in evaluating the significance of the above data. This is possibly open to some doubt, but it will serve as a means of illustrating the method.

Nitrogen.

Mitscherlich does not attach undue significance to the increased yield from nitrogen, due to the fact that it is virtually impossible to determine the maximum yield for this plantfood. Only one PK pot is therefore included in the series; compared with the "complete" treatment, we have:

"Complete" fertilizer	100%
No nitrogen	31.3%

The per cent. increase over the "no nitrogen" pot is therefore 219.5 per cent. From the table we find that this is equivalent to 80.5 lb. of N per acre-6 inches (depth of soil in the pot)—or 161 lb. per acre-foot. Generally a somewhat higher factor is used in calculating N per acre-foot, and employing the Hawaiian figure of 2.30—

N per acre-foot = 185 lb.

Phosphoric Acid.

The yield increase for phosphoric acid was:

"6P" pots	100%
No. P pots	49.4%

The appropriate table shows that this corresponds to a value of 44 lb. per acre-6 inches: employing the factor 2.18, we obtain a figure of:

P_2O_5 per acre-foot = 96 lb.

Potash.

The yield data for potash-treated pots show:—

"Complete" fertilizer	100%
No potash	75.1%

Consulting our tables once more we find that this corresponds to 58 lb. of potash per acre-6 inches of soil: we must now make allowance for the fact that in filling the pots of the "no potash" treatment, the original soil is diluted with three parts of sand. This has been found desirable, as the indicator plant is not so sensitive towards potash as is the case with phosphate. We must therefore multiply our figure by 8—by 4 to allow for dilution, and by 2 to give our results on an acre-foot basis—therefore:—

K_2O per acre-foot = 464 lb.

6P v. 1P.

The yields from light and heavy applications of phosphate are regarded in Hawaii as a measure of the capacity of the soil to "fix" soluble phosphates in a form less readily available for crop nutrition. Comparison of the data reported above shows:—

"6P" pots	100%
"1P" pots	85.4%
Increase—6P over 1P .. .. .. =	17%

Discussion.

We are now interested in the significance of the figures calculated; here we must have access to field trials, to supply the comparative data for pot tests and field yields on a given soil. This is, of course, not available in Queensland. In Hawaii, it is suggested as an approximation that a 70-ton crop of cane requires 120 lb. P_2O_5 and 600 lb. potash: while for nitrogen, a value for the PK pot less than 40 per cent. of the "complete" is an index of nitrogen deficiency.

On this basis we could conclude that the soil in question requires nitrogen, phosphoric acid and potash, for the production of a 70-ton crop of cane. For smaller yields, which would be the case under our conditions, our conclusions would be much less definite.

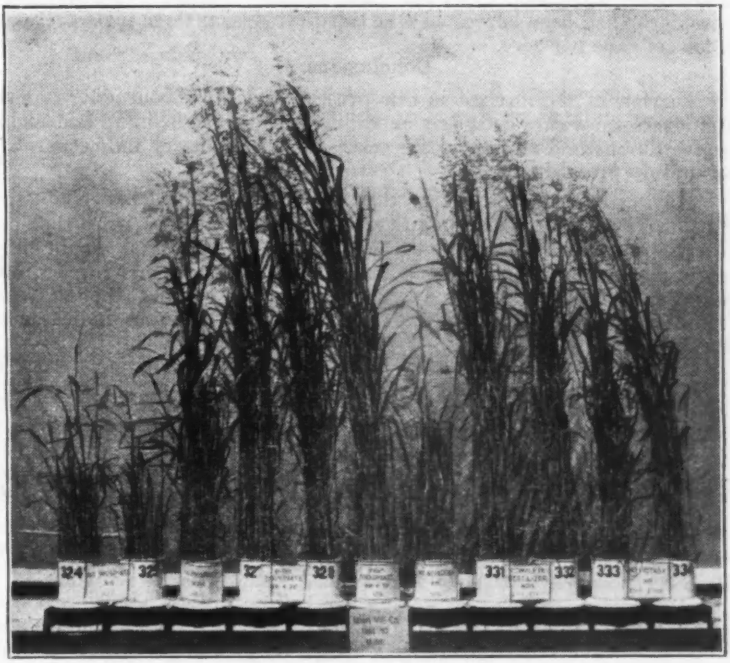


Fig. 38.—Showing a series of pots with Sudan grass as indicator plant. (Photograph by courtesy, H.S.P.A. Expt. Stn.)

We purposely selected this soil for our first pot tests, as we have the fertilizer trial results for plant and three ratoon crops. These were as follows:—

Increased Yield Due to—	Plant Cane.	First Ratoons.	Second Ratoons.	Third Ratoons.
	Tons.	Tons.	Tons.	Tons.
Nitrogen (84 lb.)	2·2	12·1	12·1	17·0
Phosphoric acid (59 lb.)	2·6	2·8	2·6	3·0
Potash (75 lb.)	5·7	7·0	3·9	9·8

It is evident that this soil is highly deficient in available nitrogen and potash, while a definite yield increase is also obtained from superphosphate. As the yield increases recorded in this experiment are seldom

exceeded under Queensland conditions, it must be concluded that the pot trial did not give clear-cut and decisive results. Indeed, it leaves us rather vague on the true significance of the test values.

It should be pointed out further, that the soil sample employed in the pots was taken from the "no fertilizer" plots, after the third ratoon crop had been harvested; the third ratoons on these plots averaged 13 tons of cane per acre.

Conclusions.

In view of the interest in this project, and the encouraging reports from overseas, we are definitely extending our pot trials, in an endeavour to give the method an exhaustive test. But preliminary indications are not unduly promising.

Having regard for the fact that our rapid chemical phosphate test gives us a high degree of reliability, and the general experience that pot test results for nitrogen cannot be stressed, the pot trial would offer greatest hope for determining potash deficiencies. In this respect, our Hawaiian colleagues report a good measure of success, though from Trinidad (1) it is reported that Sudan grass fails as an indicator of potash deficiency.

REFERENCE.

(1) Innis, B. de L., Tropical Agriculture, Vol. XIII., No. 11, p. 292.

Review of Results from Fertility Trials in North Queensland.

By H. W. Kerr.

Introduction.

In 1929 the Bureau of Sugar Experiment Stations instituted the farm fertility trial project. To date, we have the results of seven years' effort, and it would appear opportune to review these results, for the purpose of extracting any general conclusions which appear warranted, and to indicate in which directions our future efforts should be concentrated.

It is recognised that the results obtained from an experimental area on one farm are specific for that area alone; but at the same time, when we have accumulated similar evidence from a series of such trials, on areas of similar soil type, we are justified in generalising our advice for the soil type as a whole. After all, our recommendations are based on but three classes of mixed fertilizer, which are, at the present time, adequate for our needs; as we cannot in the present state of our knowledge, draw finer distinctions between fertilizers of similar composition, or even designate to the nearest 50lbs. the quantity of fertilizer per acre which should be applied from year to year, no further refinement is demanded. We must remember, also, that the quantity of fertilizer which a farmer purchases is often governed not only by the needs of his land, but by the length of his purse.

Soil Types.

Our soil survey officer has provided us with maps of the Northern cane soils, and has classified them largely on the basis of their origin

and mode of formation, into a number of major types, with minor variants. The major types are:—

(1) Granitic alluvials,
(2) Granitic residuals (usually sandy and gravelly loams),
(3) Schist alluvials,
(4) Red schist residuals,
(5) Red volcanic loam.

They occur in greater or less amounts, in all areas from Mossman to Tully: there are no schist alluvials in the Tully or Babinda areas, while red volcanic loams are absent from the Mossman and Tully districts.

These distinctive types have been kept in mind in the selection of sites for fertility trials, so that at the present time we are in possession of information regarding each major series, in addition to more specialised knowledge on minor variants.

(1) Granitic Alluvials.

This class embraces many of the river and creek flat soils of the Mossman, Mulgrave, Babinda and Innisfail districts. In their behaviour towards fertilizers, we find that they are frequently acid, and in need of liming. They also exhibit deficiencies in available phosphates and nitrogen, but are usually well supplied with available potash. An excellent example of this soil type is the Tropical Agricultural Station, South Johnstone, which was conducted for many years as a sugar experiment station. Our experiments showed consistently good and profitable results from the frequent use of lime, and the consistent applications of fertilizers rich in phosphates and nitrogen.

A number of our farm trials have been located on this type. A summary of the results gives the following average increase from modest application of nitrogen (as sulphate of ammonia), phosphoric acid (as superphosphate) and potash (as muriate):—

TABLE I.

Granitic Alluvial Loams.

Yield Increase Due to—	Plant Cane.	Ratoon Cane.
	Tons.	Tons.
Nitrogen (N)	2	5
Phosphoric acid (P)	5	6
Potash (K)	1	2
Total	8	13

The consistency over a range of trials confirms the general recommendations of the Bureau, for the use of Sugar Bureau No. 1 fertilizer mixtures, which are rich in phosphates and poor in potash. It will be observed that there is a marked increase for nitrogen on ratoons, whereas the plant cane response is relatively slight. Sulphate of ammonia should therefore be applied consistently to ratoons, even when green manuring has been practised prior to planting.

We have also the results of quantitative fertilizer trials on this soil type, which were designed to tell us the most profitable application per acre.

Though these are insufficient to allow of any fine conclusions, they indicate the need for the following:—

—	Plant Cane.	Ratoons.
Initial treatment.. ..	4 cwt. per acre, Sugar Bureau No. 1 Planting Mixture in drill	4 cwt. per acre, Sugar Bureau No. 1 Ratooning Mixture, when ratooning
Top dressings	2 cwt. per acre, sulphate of ammonia as top dressing (if farmer has not green manured)	3–4 cwt. per acre sulphate of ammonia, in two top dressings; the heavier application for old ratoons

(2) Granitic Residuals.

This class includes the characteristic gravelly loams of Babinda and Tully, as well as smaller areas of red granitic slopes at the foothills of certain districts. In spite of their low water-holding capacity, they are productive types in high rainfall areas, provided liberal fertilizer applications are made to maintain the available plantfood supply. In their behaviour towards the individual nutrients, they are rather similar to the granitic alluvials, as is shown in Table II.: this summarises the results to date on the gravelly soils.

TABLE II.

Granitic Gravelly Loams.

Yield Increase Due to—	Plant Cane.	Ratoon Cane.
	Tons.	Tons.
Nitrogen (N)	4	6
Phosphoric acid (P)	2	2
Potash (K)	0·5	2
Total	6·5	10

It will be observed that these soils give generally a higher plant cane response to sulphate of ammonia than do the alluvials; this is to be expected, when it is remembered that these soils are very deficient in humus. The yield increase due to phosphate is relatively slight, and we have some indication of a slight potash deficiency in ratoons.

On the basis of quantitative trials carried out on this soil type, we offer the following general recommendation:—

—	Plant Cane.	Ratoons.
Initial treatment.. ..	3–4 cwt. per acre, Sugar Bureau No. 1 Planting Mixture in drill	3–4 cwt. per acre, Sugar Bureau No. 1 Ratooning Mixture, when ratooning
Top dressings	2–3 cwt. per acre sulphate of ammonia as top dressing (if farmer has not green manured)	3–4 cwt. per acre sulphate of ammonia, in two top dressings

(3) Schist Alluvials.

This soil type is generally not "pure" in character, as the silts from which it is built are usually of mixed granitic and schist origin; we therefore apply the name to soils which are purely *or* predominantly of schist origin. Soils of this class constitute some of the most highly productive lands of the North.

Due probably to the lack of uniformity in the parent material from which these soils are formed, they exhibit marked variations in their behaviour towards artificial manures. It is generally true that they display definite nitrogen deficiency, and some remarkable yield increases are obtained from applications of sulphate of ammonia. The remarks for residual schist soils should be consulted for further comment on schist loams in general.

(4) Red Schist Residuals.

This soil type is one of the major cane soils of North Queensland. The general colour is red, and for this reason they are often confused with volcanic loams: indeed, the line of demarcation is particularly difficult to define where both types exist side by side. At times a moister variation of the major type exists, and this is brown in colour: where conditions of poor drainage occur, a characteristic white soil is obtained.

These soils as a class have been studied more extensively than any other type in North Queensland. This is the result of the lack of agreement obtained from areas even in close proximity. They are uniformly deficient in humus, and consequently, in available nitrogen: they therefore give good response to sulphate of ammonia. In certain cases an application of 4cwt. per acre has given increases ranging from 10 to 17 tons of cane per acre, with ratoons. As regards their reaction to phosphates and potash, we find sometimes one, sometimes the other is dominating, while on other occasions, both are in substantial demand.

The summarised results of Table III. illustrate this fact.

TABLE III.

Schist Loams.

Yield Increase Due to—	Plant Cane.	Ratoon Cane.
	Tons.	Tons.
Nitrogen (N)	3·4	8·4
Phosphoric acid (P)	2·5	2·0
Potash (K)	2·1	3·0
Total	8·0	13·4

These averages show clearly the need for sulphate of ammonia on this soil type, on both plant and ratoon crops: as regards phosphate and potash, the *average* increase is sensibly equal for both plantfoods: but if

we should consider *extreme* cases, we have the following comparison, for trials located not more than one mile apart, on first ratoon crops:—

Increase Due to—	Farm "A."	Farm "B."
	Tons.	Tons.
Nitrogen (N)	3·8	12·8
Phosphoric acid (P)	4·8	2·8
Potash (K)	0·4	7·0

To quote another example, from a trial on red schist soil at South Johnstone, we found:—

Increase Due to—	Tons.
Nitrogen	2.2
Phosphoric acid	9.2
Potash	1.5

To generalise, then, we would offer the following advice; this will cover probably 75 per cent. of schist lands. It is best, however, for farmers on this class of soil to submit a sample for chemical analysis, as this can be relied upon to tell us the true state of the soil with reference to available phosphate, and to indicate the need or otherwise for potash; a specific recommendation then becomes possible.

—	Plant Cane.	Ratoons.
Initial treatment	3–5 cwt. per acre, Sugar Bureau No. 2 Planting Mixture, in drill	3–5 cwt. per acre, Sugar Bureau No. 2 Ratooning Mixture, when ratooning
Top dressings	3 cwt. per acre sulphate of ammonia, in two top dressings	3–4 cwt. per acre sulphate of ammonia, in two top dressings

(5) Red Volcanic Loam.

Substantial areas of this soil type are found in the far North, notably in the Innisfail and Babinda districts. The virtues of this soil from the point of view of its tillage qualities have frequently been extolled. It is also very interesting in its reactions to fertilizer, as it is the chief soil type which shows a definite and consistent potash deficiency: it is rarely if ever lacking in available phosphate, while yield-increases from sulphate of ammonia, even on ratoons, are not outstanding.

Applications of from 300-500lbs. of muriate of potash per acre have produced crop increases ranging from 6 to 14 tons of cane per acre, on plant cane. The highest increase was recorded on a field characterised by the presence of "sterile patches" which is so frequently strong evidence of potash deficiency on soils of this type.*

* This should not be confused with similar patches on alluvial country: they usually denote excessive acidity and phosphate deficiency.

With ratoons, the crop increases for progressively heavier applications of potash are not so marked as for plant cane: and it would appear that the consistent application of 2cwt. of muriate of potash per acre is sufficient for customary yields. It is interesting to note, also, that the use of potash on this land influences the C.C.S. of the crop grown thereon, and farmers may expect permanent benefits from the practice. Our recommendations for red volcanic soils are as follows:—

—	Plant Cane.	Ratoons.
Initial treatment.. ..	4–5 cwt. per acre, Sugar Bureau No. 3 Planting Mixture, in drill	4–5 cwt. per acre, Sugar Bureau No. 3 Ratooning Mixture, when ratooning
Top dressings	2 cwt. per acre, sulphate of ammonia as top dressing (if farmer has not green manured)	2–3 cwt. per acre, sulphate of ammonia as top dressing

Notes on Farm Horse Rations.

By D. L. McBRYDE.

IN the July, 1935, issue of the *Cane Growers' Quarterly Bulletin* an article on "Feeding Farm Animals" was presented. This arose out of a discussion on farm horse rations which took place at the Bundaberg Conference in April of that year; while many farmers contended that they were able to maintain their animals in good working condition on a ration consisting of "chop," molasses and linseed meal, others were equally emphatic that it was essential to employ maize or some other grain in the feed.

It is well recognised that molasses is the cheapest form of carbohydrate available on the cane farm, and that horses are able to utilize from 6-8 lbs. per day without detriment. It therefore replaces, theoretically at least, the starches supplied by maize, though it is not so rich in proteins.

In order to test the value of this feeding material, the farm horses at the Mackay Experiment Station were placed on a ration of "chop-chop" (or other roughage during the slack season), molasses and linseed meal, with a small addition of mineral lick.

Standard Ration.

The horses are fed three times daily during the working week, twice on Saturday, and once on Sunday, while they are in constant work. At other times, if the paddocks are bare, as is usually the case during winter and spring, two feeds are given daily, except on Sunday, when the animals are fed once. If there is good grass in the paddocks, only one feed is given daily during periods when the horses are idle or in light work.

The components of the feed, and the approximate quantities given are:—

Chop-chop	18 lbs.
Molasses (heavy)	2 lbs.
Linseed meal	1 lb.

These quantities are adhered to by employing measuring tins; in addition, about 1 oz. of lick per day is supplied, to make good any mineral deficiency.

When cane tops are not available, panicum or guinea grass, or both, are chaffed for the horses. This feed is usually cut in sufficient quantity to carry through for two or three days, and except for the needs of the first day, the grass is allowed to dry for a short period before it is taken to the barn.

It is of interest to study the true feeding value of the above-described ration, to determine whether it agrees with the generally accepted standards.

The analyses of the materials are as follows:—

Feedstuff.	Crude Protein.	Crude Fat.	Crude Fibre.	Crude Carbohydrate.
	%	%	%	%
Chop-chop	1·6	0·7	9·0	16·9
Molasses	5·9	—	—	50·0
Linseed Meal	31·4	6·4	10·2	36·8

Making due allowance for the quantity of each in the ration, and the digestibility of each nutrient contained therein, the following amounts of nutrients are given daily:—

Feedstuff.	Dry Matter.	Digestible Proteins.	Total Digestible Nutrients.	Nutritive Ratio.
	lb.	lb.	lb.	
Chop-chop—54 lb.	16·2	0·2	11·3	—
Molasses—6 lb.	4·5	0·1	4·7	—
Linseed Meal—3 lb.	2·7	1·0	2·4	—
Total	23·4	1·3	18·4	1 to 11
Minimum requirements	23·4	1·8	16·9	1 to 8

Discussion.

It will be observed that, without making any allowance for the value of grass obtained by grazing, the animals receive an abundance of dry matter, which is rather rich in total nutrients, but slightly deficient in digestible proteins. It would therefore be an advantage to increase the linseed meal, or substitute portion by a meal richer in proteins and lower in fat.

The accompanying photograph (Fig. 39) shows the condition of the animals at the conclusion of the past harvesting season, when they had been fed this ration for eighteen months. It is found that the horses fatten between spells of steady work, but do not soften as their appearance might suggest. They come back into hard trim without any trouble, such as is the case, at times, when horses are given a heavier ration of molasses.

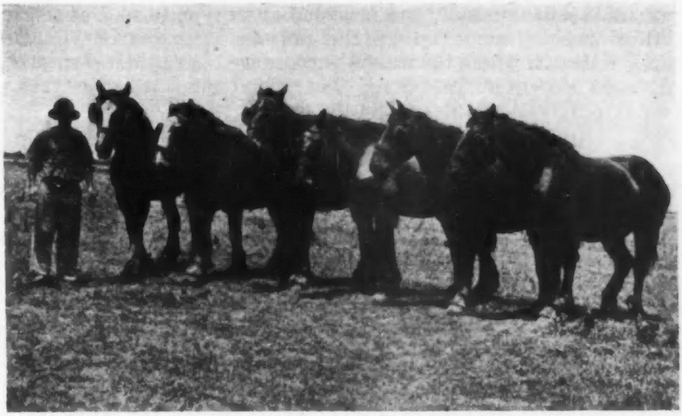


Fig. 39.—Farm horses on Mackay Experiment Station, at the conclusion of the harvesting season.

A noticeable improvement since adopting the above feeding systems was that of the condition of skin and coat, which lost all signs of scurf. This improvement was due, undoubtedly, to the linseed meal. Factors operating during the past eighteen months were decidedly against the well-being of the animals, particularly from May, 1935, to February, 1936, when the horses were without shade or protection from the weather. It might be stated that the horses get little, if any more grooming than would the usual farm horse.

Irrigation Waters of the Burdekin Delta.

By N. G. Cassidy.

THE underground water of the Burdekin delta is a subject of everyday interest, as well as of vital importance, to cane growers of the area. Many strange statements are made regarding the underlying drifts, and queer theories are often held as to the replenishment of them. Growers will, therefore, appreciate a short account of what is definitely known about the water-bearing beds and what conclusions can reasonably be drawn from a knowledge of the facts.

The gravel or sand "drifts" in which the water occurs cannot be mapped out in any simple way on account of the variety of conditions existing. At one particular spot a band of clay may separate streams which are shown by analysis to be quite unlike each other, and, contrary to expectation, the top supply may be more salty than the lower one.

However, on proceeding from district to district, certain tendencies are evident, and it is possible to divide the area into three zones. The inland districts of Airedale, Maidavale, Pioneer, Dick's Bank, Klondyke, as well as most of Home Hill, comprise the first zone. The waters obtained under these districts have a "family" resemblance to one another, and are similar in composition to the flood waters of the Burdekin River. The second zone of the Delta is made up of the coastal districts, Seaforth, Rita Island, and lower Home Hill. Here the mineral content of the waters is much greater, and it is similar in type to that of sea water. The third zone is made up by the intermediary districts, McDesme, Ivanhoe, Kalamia, where the waters encountered have their own peculiarity of a high content of free alkali. The second and third zones thus yield less suitable irrigation waters than the first.

The evidence concerning the distribution of waters of different types gives a clue to the origin of the whole supply. It suggests that, in the main, replenishment of the supply takes place by flood waters moving along old river channels which have been covered up but are still very pervious to water. In the intermediate zone some obstruction to free flow of water occurs, and the water takes up considerable amounts of mineral matter. In the coastal districts sea-water penetrates the drifts in places, the connection between the two bodies of water being clear from the rise and fall of level which take place with the tides.

These conclusions are well supported by evidence of the rise in level of bores, subsequent to flooding in the river. The immediate response in the first zone of the area is contrasted with the lesser sensitiveness of bores situated elsewhere. Since neither the extent nor the time of the rise in level after rain is uniform, it follows that direct penetration of rainfall is not responsible for the renewal of underground supplies, particularly when the quality of the water is found to vary from district to district. It should be pointed out that the underground supplies could not possibly be derived from the sea, as the brine could not be removed by any natural process of filtration. Everything indicates that river flooding is the principal source of replenishment and, moreover, the evidence available does not point to any permanent depletion of the supply.

It is of interest to compare the quality of Burdekin waters with that of rivers and irrigation waters in other parts of the world. Such a comparison shows that Burdekin waters in general have an unfavourably low ratio of "hardness" to "salt." In other words the mineral matter of the waters contains too small a proportion of calcium, or "lime." This may cause grave damage in extreme cases, especially when regular waterlogging of the soil is allowed to take place. Recent investigations show that even when the chemical action of salty water on the soil has only proceeded to 30 per cent. of the maximum extent possible, the soil has already suffered the maximum damage to its physical condition that it can undergo. All this illustrates the need for care in the use of the right kind and amount of irrigation water. A bad supply may possibly be improved by sinking deeper, or by lifting the spears. At all times of doubt a sample may be sent to the Bureau for analysis and for comparison with any previous tests. Except near the sea-coast any particular bore generally yields water of very constant quality from year to year.

For a fuller discussion of this subject growers may obtain, free, on application to the Bureau of Sugar Experiment Stations, the original article published as Technical Communication No. 1 (1937).

Some Notes on Rat Control in the Mourilyan Area.

By E. H. Fox.

ALTHOUGH a good deal of rat control work had been attempted intermittently by the various Northern pest boards prior to 1934-35, the problem had only occasionally assumed serious proportions, and was usually considered a matter for local, even individual, attention, rather than one of major interest to the industry as a whole.

When it became necessary, therefore, to commence large-scale control operations, the necessary published data for their success were virtually non-existent, and most field investigators had to commence with the "trial and error" method, picking up such information as came their way during the more pressing business of practical attempts at control. It was assumed, at least among the majority of farmers, that a rat was simply a rat; a poison, poisonous; and any foodstuff a suitable medium for carrying the poison.

Undoubtedly there were a number of excellent formulæ in existence, giving lethal dose and recording details of tests, but many of these had been evolved for the destruction of house-rats, and few, if any, had been carefully checked under Queensland field conditions. However, they formed a basis on which to start work, and because of the urgency of the position, it was not long before new clues were being unearthed and exchanged and the classification and description of species under way.

Results at Mourilyan, as elsewhere, have often been confusing; success, for instance, under one set of conditions has often become failure under what appeared to be similar conditions; but certain broad conclusions or at least tendencies can be traced, and may be worth testing in other districts. It should be noted that our captures, alive and dead, suggest that over 90 per cent. of our field rats belong to the *Melomys littoralis* species, also that the destruction of harbourage has been actively pursued simultaneously with poisoning campaigns, and has undoubtedly brought results, and this, combined with the impossibility of evolving a check on field operations, renders more complicated the question of effectiveness of poison baits.

The evidence is overwhelming in favour of continuing poisoning operations, however, under our local conditions; thus the use of thallium-coated wheat has given 100 per cent. kill in dozens of cage tests, packets laid in fields showing extensive rat damage have been opened and the contents eaten, occasionally dead rats having been found, and in many cases damage to cane has ceased—temporarily. Certainly not in all cases, but whilst one such case noted could be passed over as an accident and the second as a coincidence, when it happens fairly regularly it seems logical to assume a measure of success for the method. It was admitted, of course, and still is, that there are probably factors operating which are neither controlled nor understood.

These activities soon pointed to another important question—what constitutes the adequate baiting of a paddock? Our most striking successes had been obtained under conditions of very lavish baiting (of the order of 2,000 baits per acre) and anyone who has attempted

the baiting of a badly infested paddock of lodged cane will realise the absurdity of putting down a few hundred baits around the headlands of a large paddock. Having once admitted the poisoning method as a handy and more or less effective one for the destruction of rats, it naturally followed that a more regular and complete baiting of paddocks was desirable if it could be accomplished economically.

A three-weekly issue of 1,000 baits for every farm in the area, whether rat infested or not, was aimed at as a minimum, with large reserves for those farmers who, because of extensive damage, either applied (themselves) for more or were advised that they required more. Obviously thallium wheat baits were too expensive to be used on such a scale, so other types were tested, and finally bread and phosphorus baits, as described below, were used for the regular campaigns in dry weather, with packeted wheat as an occasional change and for wet weather application.

The results of our cage tests showed:—

(*a*) One hundred per cent. kill in all cases within twelve hours of the rat taking even the smallest bite.

(*b*) The tinted, or poisoned, face of the bread cube was apparently the most palatable.

(*c*) Baits appeared to retain their palatability and potency after being kept one month in an airtight tin.

(*d*) Baits were still potent after twenty-four hours in the paddock.

The method of manufacture is still being improved, but consists at the moment in slicing large sandwich loaves into twenty-eight to thirty slices, laying them on a board which is constantly being smeared with phosphorus paste (made to Dr. Cilento's formula), dipping the sticky face in a mixture of flour and sugar, and finally cutting the slices into cubes by means of a cheap salad cutter. The cubes are then put into 4-lb. bags, labelled, and packed in air-tight tins for delivery.

It is possible to cut 4,000 baits from a double sandwich loaf, and the fresher the bread the more easily will it be found to cut. Instead of brushing the thick paste (previously warmed) directly on to the bread, it saves time to smear it on a heavy, shining surface, such as marble or a piece of thick glass, by means of a paint brush, and to press the slice down firmly on this. It is also found advisable to carry each process through quickly without any accumulation at each step, because of the rapid drying of the bread, with the consequent difficulty in cutting it.

The salad cutter, costing about 2s., is imply a series of thin sharpened metal discs, 3 inches in diameter, revolving on a common spindle and encased in a metal guard. It is capable of improvement for this work—a heavier and stouter one would handle the crusts better. Indeed, refinements are no doubt possible throughout all stages of manufacture, but the following figures of actual costs will serve to show how cheaply these baits are being prepared. Costs of supervision and delivery are not included. The cost of carriage on phosphorus paste is included, but, if carried freight free, it would reduce this charge from 1s. 8d. per lb. to 1s. 3d., reducing the total cost of baits to about 8d. per 1,000; whilst, if mixed on the premises, this charge of 1s. 8d. per lb. for phosphorus would be still further reduced to 8d. per lb. or less.

Cost of manufacturing 180,000 phosphorus rat baits:—

	£	s.	d.
45 double loaves at 10d.	1	17	6
45 lb. phosphorus paste at 1s. 8d. ..	3	15	0
Labour (youth, 2 days)	0	16	8
Flour and sugar	0	6	0
Bags	0	1	8
Labels	0	3	0
"Clag"	0	0	6
	£7	0	4

or a little over 9d. per 1,000 baits.

Their small cost has enabled us to lay a total of 1,386,000 baits over a comparatively small of approximately 8,000 acres net in nine months, and in the writer's opinion this is lower than the minimum needed for prevention of damage, and considerably lower than that required for clearing up harbourages already heavily infested. Damage throughout the area last year was so low (from whatever cause) that we feel justified in continuing our present methods even more extensively until such time as a better method of control is evolved, or unmistakable proof is forthcoming that we are drawing wrong inferences.

The Use of Unsuitable Fertilizer Mixtures.

THE correct fertilization of any crop lies in the ability to supply to the soil those particular foods required by the plant which the soil is unable to supply.

With a view to obtaining this information the Bureau of Sugar Experiment Stations has for the past eight years carried out numerous fertilizer trials on different farms covering a wide range of soils. This collection of a vast amount of data enables us to gauge with accuracy the particular type of fertilizer which will give the most payable return on any particular soil type. In view of this information special fertilizer mixtures have been compounded to suit these soil types, and are known as Sugar Bureau Mixtures Nos. 1, 2, and 3.

It is surprising, after the amount of publicity given these results and the recommendations made, to find that farmers are frequently using mixtures that are both more expensive and unsuitable. A good example is the use of a high-potash mixture on the acid alluvial lands, where a cheaper mixture containing more phosphate and less potash will give a larger tonnage. Another illustration is the use of high-phosphate mixtures on red volcanic soils, which require lots of potash. Such a mixture, while cheap per ton, is expensive in the long run.

If there is any doubt that the correct type of fertilizer is being used, an inquiry directed to the nearest officer of the Bureau of Sugar Experiment Stations will receive attention.

G.B.

A Modified Irrigation Method.

By B. Tapiolas.

IN a paper on "Irrigation Principles" presented by Kerr at the 1933 Conference, brief reference was made (Proceedings, p. 104), to a method of "one-side" irrigation, which was being tested in the Burdekin area. The writer has given further close study to the method since that time, and is now able to report that it has been developed into a very satisfactory scheme for both plant and ratoon cane irrigation.

The characteristics of the Burdekin alluvial soils were accurately described by Kerr and Cassidy*, and the difficulty in keeping these soils in a well-cultivated state between waterings is one of the biggest problems the farmer has to contend with. The ill-effects of the water on the soil also increases the difficulty of raising satisfactory crops, and this is particularly true of ratoons. The writer has therefore concentrated his attention on a method which would bring about the following improvements:—

(1) Reduction in the number of cultivation operations necessary.

(2) Water economy.

(3) Assistance in the retention of a favourable tilth in the surface soil, by minimising the ill-effects of water and implements.

Early efforts were confined exclusively to ratoons, and an implement was devised which would enable the cultivation of the land to be carried out in a few operations. At the present time, the standard ratooning practice is as follows:—Bumper discing, to create a surface mulch and level the land; ploughing away from both sides of the stools; subsoiling or grubbing; scarifying to level the interspace; preparing water furrows for irrigation; surface cultivation to restore tilth; hilling-up, in preparing water furrows; scarification, &c., after each watering, and the necessary repairing or re-shaping of water ditches before each subsequent irrigation. By the improved method, the number of operations is reduced to the following:—Bumper discing; ploughing away; sub-soiling to 15 inches, and preparing 10-inch furrow close to one side of the cane stools, all in one operation. As many as four light waterings may then be given, before cultivation for weed control becomes necessary, as the manner in which the water is applied keeps the surface soil of the interspaces dry, and the soil tilth is therefore not destroyed. When it becomes necessary to check weed growth, this is done by one operation with the combined implement. By this time the ratoons are well advanced in growth, and thereafter, watering only is necessary.

A brief description of the implement, assisted by the accompanying sketches and photographs, should make the essential features clear. It was built up by the writer from portions of old implements on the farm. To a standard tractor-grubber frame three mouldboard ploughs were attached in a special manner (*see* Fig. 40). A pair of 7-inch ploughs placed at a distance of about 24 inches between share points, were so attached as to throw a light furrow *on* to the cane stools; they were set so as to turn the surface 3 or 4 inches of soil, and effectively smother all

* "The Soils and Irrigation Waters of the Burdekin Delta"—Q'land Agric. Jour., 1932, p. 115.

weed-growth in the cane row. Following the right-hand plough, and set at a distance of about 4 inches nearer the cane stools, is a 10-inch mouldboard plough, which turns a furrow 10 inches deep *away* from the cane row. To the tip of the wing of this plough is attached a leveller, consisting of a horizontal iron bar braced to the grubber frame as shown in the illustration (Fig. 40). To balance the implement, and to produce a sub-soiling effect, one grubber tyne with a chisel point is attached on the side opposite from the 10-inch plough, and operating towards the centre of the interspace. The effect of the implement on the soil is shown by the series of sketches (Fig. 41). The implement is drawn by a tractor straddling the cane rows.

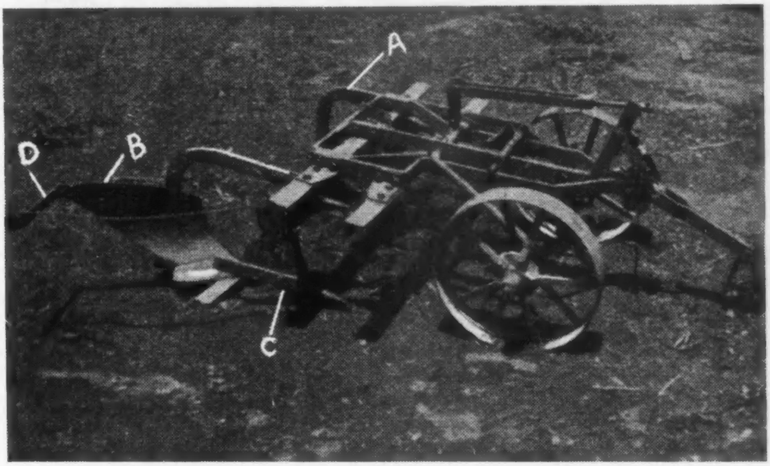


Fig. 40.—Illustrating the essential features of the combined implement—A 7-inch plough, B 10-inch plough, C subsoiler, and D leveller, attached to plough wing. *Note.*—One of the 7-inch ploughs is absent from the machine, which was arranged for simplicity in photography.

As the implement is worked in "lands" of eighteen rows, it will be obvious that the central interspace of the land will carry no water furrow; in this interspace the tramline is laid.

It was found, also, that the implement worked very satisfactorily in plant cane. The depth of the 7-inch ploughs was in this case raised by means of the adjustable beam so as to turn only the surface 2 inches of soil from either side, and thus avoid hilling of the cane; the water-furrow was run at a 10-inch depth, as for the ratoons.

After the job is completed the field is free of weeds, and thereafter watering only is necessary. The deep water-furrow ensures deep penetration of the soil and subsoil, while the interspace surface remains quite dry unless rain should fall. Weed growth is therefore prevented, and the cane crop is encouraged to develop a deep rooting system, which means resistance to drought. On lands where rather saline waters are being used the upward rise of water and concentration of soluble salts in the surface soil is also prevented. The fact that cultivation is reduced to a minimum also gives the soil a chance to recover its crumby structure, and makes for a permanent improvement in the tilth of the

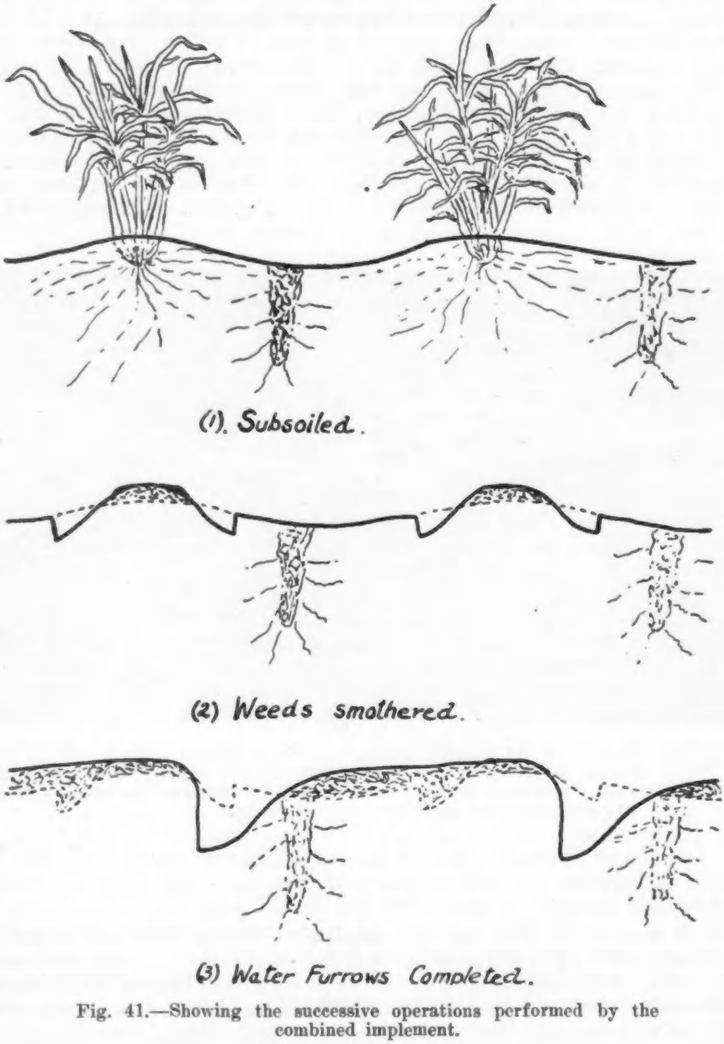


Fig. 41.—Showing the successive operations performed by the combined implement.

land. The method markedly increases the area which a man can irrigate daily, while bringing about an economy in water utilization amounting to probably 30 per cent.

The writer would state quite definitely that the modification in irrigation procedure as described above is the biggest forward step he has taken since he adopted the use of artificial manures as a standard practice.

Cane Soils of North Queensland.

By N. J. KING.

THE canegrowing soils of North Queensland were discussed at the last Cairns Conference.* The maps submitted at that time were based on a preliminary soils survey carried out in 1930. During the latter half of 1936 the writer made a more detailed survey of these far northern areas supplying the Mossman, Hambledon, Mulgrave, Babinda, and Goondi Mills. The work will be continued as opportunity offers.

Several alterations and amendments were made in each mill district and the increasing volume of information being collected by the northern field officer, and per medium of fertility trials, makes possible a more detailed study of these soils. At the same time field experimental programmes are being vigorously pursued by several of the mill staffs, and the writer is particularly indebted to the staffs of Mulgrave and Goondi Mills, whose co-operation was of considerable value. The soil analytical survey initiated by the former mill should be of inestimable value to the suppliers in furtherance of an intelligent fertilizer programme.

Mossman.

Sugar cane agriculture in this area may be described as being carried out in a series of valleys and flood plains. Practically the entire area is alluvial, with only small agricultural development on the hillsides. On this account the cane area is not continuous. The more fertile land has been selected and assigned, leaving undisturbed poorer tracts of forest country between such fertile valleys. The flood plains of Whyanbeel and Saltwater Creeks, Mossman and Little Mossman Rivers, Cassowary Creek, and the Mowbray River and their tributaries cover the cane producing areas of this district.

Geologically, the alluvial soils are derived partly from schists and partly from granite. The influence of the latter is not noticeable except in the Whyanbeel Valley and on the Syndicate line. In these places the soils are usually gravelly—the small quartz particles from the granite having their influence in giving the soils an open structure of unmistakable granitic origin. In all other cases the Mossman alluvials are developed from schists, but during the processes of soil formation and flooding much mixing has undoubtedly taken place. It is probable that the large tracts of non-gravelly country are mixed schists and granitic alluvials, the gravel having separated out as the flood waters moved more slowly. The gravel is therefore found near stream banks or at the base of granite ranges.

The characteristics of these Mossman alluvial soils are (1) their general acidity, (2) fine particle size—they might be classified as a fine sandy clay-loam, (3) great depth of soil without change in structure, (4) uniform buff colour, (5) good moisture holding capacity, and (6) fair drainage. The soil surface is inclined to set somewhat after rain owing to the very fine sand present, but the crust is easily broken by light cultivation. The fertilizer requirements are firstly lime in most cases, and then applications of Sugar Bureau Mixture No. 1 with top dressings of sulphate of ammonia. In most fertility trials on this soil type excellent response has been obtained to phosphate and nitrogen,

* Some notes on the Soils of the North Queensland Sugar areas, by G. Bates.

with very few instances of gains from potash. Much money is being wasted annually in this district by indiscriminate fertilizing. It should be borne in mind that potash is one of the most expensive ingredients of mixed fertilizers and that soils of the Mossman alluvial type do not require a mixture rich in potash.

Occasionally one finds in these alluvial areas patches of whitish soils which appear to have all the general characteristics of the buff type, except colour. These whitish patches are usually associated with bad drainage, and should be treated as a poorly-drained area. The influence of drainage will be noticed in the improvement of crops and the gradual disappearance of the white colour.

The other soil types of the area which appear in small sections are (1) red schist, (2) red granitic, (3) talc schist, (4) stony schist alluvial, and (5) chocolate sandy soils. Small areas of red schist soil occur on hillsides on the edge of Saltwater area, on Bonnie Doon Estate, along Cassowary Creek, and in the Mowbray Valley. The red granitic soil covers only a small area on the north-west corner of Mango Park Estate. The talc schist soils occur on the south bank of the Mowbray River and the stony schist alluvials along Spring Creek.

The chocolate sandy soils occur near Mossman Beach. The most important of these types is the red schist, and this is discussed as a major soil type in the Hambledon area.

Hambledon.

In this Mill area cane growing is confined to three major types (1) the Barron alluvial, (2) the red schist, and (3) the ancient buff alluvial which is in most respects similar to that at Mossman.

The Barron alluvial soils can be classified as among the richest in Queensland. Their origin is bound up in the red volcanics of the Tableland, and the granites and schists of the Barron gorge. Almost annual flooding keeps up the fertility, particularly in regard to potash, but fertility trials have shown responses to phosphates (as with all other alluvial soils) and a marked crop reaction to nitrogen. There are many textural variations within the type, from very sandy soils to very heavy clays, but the average is a sandy loam of excellent texture and considerable depth. Moisture holding capacity is good. At about 18″ the soil becomes heavier, but not so clayey as to impede good drainage.

The red schist soils form, by area, the most important type of this district. They extend through Redlynch and Jungara up to the Intake on each side of Freshwater Creek; also through Edgehill and down to Wright's Creek on the east slopes of the range. Similarly most of the soils in Sawmill Pocket fall within this type. These red soils are not volcanic though frequently misnamed as such. Their chief characteristics are (1) reddish colour, (2) considerable depth without a marked subsoil, (3) droughty nature, (4) peculiar reaction to fertilizers. Their red colour is due to iron oxide, which varies from 2 per cent. to 12 per cent., the higher figures being obtained in the Redlynch area (*cf.* red volcanic soils in which iron oxide is between 22 and 25 per cent.). The droughty nature is associated with low clay content giving a poor moisture holding capacity. Fertility trials on red schist soils from Hambledon to Tully have given puzzling results. Always a response to nitrogen is obtained, but similar soils on two adjoining farms will sometimes give response to potash in one case and to phosphate in the other. This is explained by

the northern field officer (Mr. Bates) as being due possibly to previous farm history. In the early days of cane farming the only fertilizers used were meatworks, bone, and offal—all rich in phosphates. The stage was eventually reached when potash deficiency developed and a response to potash would naturally result. On newer farms the normal phosphate deficiency of these soils and fair potash content manifests itself in giving phosphate responses to fertility trials. Advisory work on such lands is therefore intimately bound up with previous agricultural history. The chief defect of these soils is their low water holding capacity, and every effort should be made to improve this factor by a programme of green manuring and trash conservation.

The ancient buff alluvial soils are similar in most respects to those in the Mossman area, but are generally less acid; a similar fertilizer treatment is recommended.

Small areas of other soil types exist. The red volcanic soil occurs at Greenhill Estate and responds to a mixture rich in potash and nitrogen —as do other red volcanic soils. White soils occur on the flood plain of Skeleton Creek in the neighbourhood of Robert's Road, and in small areas at Sawmill Pocket. A mixed brown soil derived from admixture of red schist and alluvial occurs near the Carivonica School and just north of White Rock on the main road.

Mulgrave.

It is difficult to separate this from the previous mill area by any sharp line of demarcation. The soil types continue unbroken through each area. The red schist, ancient alluvial, red volcanic, and mixed schist-alluvial soils all occur in this area also. The recent alluvial soils along the flood plain of the Mulgrave can be closely correlated with those of the Barron. The only new soil type is the granite alluvial occurring from Aloomba to Fishery Creek.

The red volcanic soils in this area occur (1) just opposite the Experiment Station at Meringa, (2) a small development in Portion 65, parish Grafton, and a large tract on the south side of the Mulgrave in the upper part of the valley. Another small area also occurs in the Little Mulgrave. These soils are renowned for their excellent tilth, ease of cultivation, great productivity, and response to potash-containing fertilizers. They are also well known for the grub damage occurring thereon. They are well drained, but owing to their high clay content do not suffer from drought to the same extent as the red schist soils. Sugar Bureau Mixture No. 3, with sulphate of ammonia, is the recommended fertilizer treatment. The area opposite the Experiment Station is surrounded on all sides by red schist soil, and owing to the similarity in colour it is difficult to differentiate the two types. Three samples taken here show by analysis the gradation from the red volcanic to the red schist.

Soil Type.	pH (Water Suspension).	Avail. P_2O_5	Avail. K_2O per 100 gm.	Fe_2O_3
		p.p.m.	M.E.	%
Red volcanic	6·8	245	·40	18·6
Mixed volcanic and red schist ..	6·6	125	·30	15·9
Red schist	6·7	54	·37	6·5

The granitic alluvial soils first appear in the gorge south of the Pyramid and extend west and south through Charringa, Meerawa, to the southern boundary of the mill area at Fishery Creek. These soils contain much fine quartz gravel, but also have a good clay content and moisture holding capacity. Much of the land of this origin is even swampy and unsuitable for cane production. Such soils respond to nitrogen and phosphates, there being usually sufficient potash present from decomposition of felspars and mica in the granite. It is difficult to detect accurate soil boundaries in parts of this area. From the Pyramid working east one traverses red schist soil, mixed schist and old buff alluvial, buff alluvial, recent Mulgrave alluvium, and on the southern boundary of some of these types occurs the granitic alluvial soil. It is apparent that much soil mixing has developed at the various boundaries, but fortunately all alluvial soils—irrespective of their origin—appear to have similar fertilizer needs. The red schist development disappears at Aloomba, the ranges further south being principally granites and gneisses.

Babinda.

In this mill area the granite alluvials are the principal soil type, and conform in all respects to those encountered in the Mulgrave area. They are for the most part low-lying and rather poorly drained, much of the land being originally under palm swamps. They are of a more or less heavy nature, and, if worked too wet will form hard lumps. Hard-pan formation is common, and excellent results have often been obtained from subsoiling. The soils are almost exclusively acid (pH 3.8 to 5·4 in KCl suspension), indicating that liming should be a general practice. The excessive rainfall of this district is responsible for extensive leaching of the soils, and only systematic fertilizing can keep such lands in a state of high productivity.

On the hill slopes of the area a reddish soil demonstrates the younger granitic soil development *in situ*. These red soils are very gravelly and well drained. They are essentially a skeleton soil of quartz, felspar, and mica particles, the finer products of decomposition being washed away as quickly as formed. In an area of such heavy rainfall there would appear to be little future for such soils, the erosion factor having too great a bearing on their ultimate life.

Large tracts of rich alluvial country exist along the Russell River in the Bucklands Road area and west beyond Bartle Frere. Similar developments occur on the south bank of the Russell between these points. This soil differs from the recent Barron and Mulgrave alluvials in appearance—probably on account of difference in origin—but the fertilizer deficiencies are similar. The soil is brownish, free of gravel, rather heavy in texture, and contains much mica. It is usually acid. The soil is deep, but subject to hard-pan development at plough depth.

Red volcanic soils occur in Babinda area at Harvey's Creek, Happy Valley, Bartle Frere, and near Qunaba Estate on the south bank of the Russell. Of these the best development is at Bartle Frere where fertilizer trials have given consistent responses to potash and nitrogen, up to 500 lb. per acre of the former still showing a profitable return.

Goondi.

This mill area is remarkably compact and extends over only three soil types (1) the Johnstone alluvial, (2) the red volcanic, and (3) the extremely poor Mundoo soils.

The Johnstone alluvial differs in no way from the Russell alluvium except that the colour is somewhat lighter. Texture, origin, depth, and fertilizer responses appear to be similar, and the normal acidity of the North Queensland alluvials is again apparent in this district. Both sides of the Johnstone River contain extensive flats of this alluvial type, and the Goondi area also includes portion of the flats on the north bank of the South Johnstone River. The isolated Innisfail Estate is of similar type. Granite and schist contribute principally to the origin of these alluvials, and as in the case of the more northern river soils, phosphates and nitrogen give good responses. Lime is nearly always required.

The major portion of the Goondi district is covered by the red volcanic type—the largest development of basaltic soil yet encountered. This red volcanic is in no way dissimilar to those met further north either in origin, texture, depth, composition, or response to potash and nitrogen. The soil does not require lime.

The Mundoo red soil—with which must be included another small area at Todd's corner, north of Garradunga—has long been a problem in cane production in this area. Although red in colour, of good tilth, well drained, and subject to the same climatic influences as the rest of the district, this soil fails to produce crops of even average magnitude under the best conditions. Much of the Mundoo country has been allowed to go out of production altogether, and this fallow country cannot support even a poor growth of grass or lantana. Heavier than average dressings of complete fertilizers do not show anything like the response obtained on the adjoining red volcanic soil. A careful examination of this soil—and of the area at Todd's corner—showed the following deviations from the red volcanic:—

(1) Sand was present in the soil.

(2) The clay content was obviously low.

(3) Moisture holding capacity was very low.

(4) Veins of ironstone occurred at varying depths and pieces of quartz sometimes occurred associated with these veins.

(5) Grass and lantana growth on land now out of production was exceptionally poor.

These observations showed definitely that the soil was not a normal red volcanic. Analysis of typical soil samples from Mundoo area and Todd's corner are shown in Table I., and for purposes of comparison is included an analysis of a true red volcanic soil. The figures for phosphates and potash explain the extreme poverty of the soils; the high total iron content is important in its relation to origin. The extremely low phosphate content is also at variance with normal red volcanics, and the depressed moisture equivalent implies a lower clay content. All these factors, combined with field geological observations, led to the following theory for the genesis of this soil. During the flow of a basaltic lava there sometimes occurs the concentration at certain points of the flow of ore bodies associated with quartz veins. In such cases the quartz is usually very friable and can be reduced to sand by the fingers alone. It is thought, therefore, that the Mundoo and Todd's corner soils are developed from such concentration bodies. The presence of so much quartz sand in a basic lava, the abnormally high iron content, and the numerous ironstone veins are thus evplained. At Todd's corner the

sand phase is entirely surrounded by the normal volcanic soil, the line of demarcation from poor to good soil being sharply defined. Table I. illustrates some of the analytical figures obtained.

TABLE I.

Soil.	Avail. P_2O_5	Avail. K_2O per 100 gm.	Replace CaO per 100 gm.	Coarse Sand.	Fe_2O_3 on Sand-free Soil.	Moisture Equivalent.
	p.p.m.	M.E.	M.E.	%	%	%
True red volcanic	116	0·30	9·7	3·4	20·3	32·0
Todd's Corner	11	0·13	0·5	25·1	34·9	24·0
Todd's Corner	19	0·09	0·4	18·2	36·7	28·5
Mundoo ...	3	0·07	0·4	11·0	30·0	29·4
Subsoil of above	4	0·07	0·1	26·4	34·8	25·6

The Determination of Fibre in Cane.*

By H. W. Kerr.

THE question of fibre in cane is one of vital importance to the cane-grower, for it constitutes an integral factor of the C.C.S. formula, on which basis he is paid for his cane. And judging by the frequency with which certain aspects of the question appear in the agenda paper of your annual conferences, many growers are not entirely convinced that the methods of determining this figure, as followed by the mills they supply, are capable of yielding a true and accurate estimate of the factor.

Following on representations made by your Council, it was agreed that Mr. J. M. MacGibbon and myself should collaborate in devising a plan of investigation which should assist in clarifying the problem, and if possible, in eliminating any weaknesses which might exist in the prescribed method. This is a problem of considerable magnitude, and one which cannot be solved as speedily or as easily as we might desire. Seasonal influences themselves demand that the problem be studied over a period of years. Therefore a plan was prepared which would enable us to gauge the reliability of those phases of the work which are not based on as reliable experimental evidence as other aspects. For this reason, it was assumed that the method of fibration, leaching, and drying are reliable, provided the details of the regulation as laid down, be adhered to. The question of selecting adequate and representative sample stalks was therefore regarded as the factor which should engage closest attention.

The results of the investigation carried out during the 1936 season have been summarised and discussed in a Technical Bulletin, issued by the Bureau, which has been distributed amongst delegates; and it is my intention this afternoon to indicate briefly the several major difficulties which must receive careful attention, in the accurate determination of fibre in cane, and to suggest how far practical considerations will limit the extent to which any refinements may be pushed.

* Address to the Queensland Cane Growers' Conference, 23rd February, 1937.

Let us consider first of all, the broadest aspects of the problem, and later pursue the argument in its particular sense. Any dispute as between miller and grower is confined entirely to the question, "Is the average of the fibre percentages as employed by the miller throughout the season, a true average value of the fibre in all cane received at the mill?" If the fibre figure be over-stated, due to any positive bias in the method of selection of stalks, the fibration thereof, or the actual analysis of the sample, then the grower is being under-paid for his cane. On the other hand, the number of fibre determinations made by a mill throughout a season is so great, that any apparent error in an individual determination is not necessarily important insofar as it affects the average seasonal result. We should be quite clear on this point. A collection of reasonably accurate figures which carry always a small hypothetical bias in favour of the mill, will give an adverse result to the grower, whereas less accurate data in which the result is understated as frequently as it is overstated may give a true average figure for all samples.

This phase of the problem could be solved most simply and satisfactorily if each mill were to have full factory control whereby the actual weight of bagasse leaving the last mill could be calculated accurately, and from an analysis of which the true average fibre, for all varieties and classes of cane, as a whole, could be calculated. It is, however, not capable of supplying results for individual classes or varieties.

Next we must consider the fibre values as employed for different varieties and classes of cane, insofar as it affects the allocation of values to the farmers supplying the cane. The magnitude of this problem varies from mill to mill. In certain mills, one cane variety constitutes in excess of 75 per cent. of the cane supply throughout the entire season; moreover, standover cane does not enter, and the only classes are plant and ratoon, "green" and burnt. The major variety at such a mill would demand a daily fibre determination for each of the four classes—(*a*) plant green, (*b*) plant burnt, (*c*) ratoon green, and (*d*) ratoon burnt. Following on the results reported in the Bulletin referred to, one might feel confident that the random selection of thirty-six stalks for each of the four classes would yield a sub-sample capable of giving an accurate estimate for the cane as received during that day. This would involve the complete fibration of about twenty-four cane stalks in the preparation of the four sub-samples for analysis. Further, if the mill were to add the fresh figures for each day to the corresponding values of the previous five days, and strike a weekly average on this basis, it could reasonably be assumed that a value very close to the true figure is being employed.

This is the simplest possible case, and it has been stated in detail to show just what work is entailed. When we take the example of a mill at which probably five varieties contribute sensibly equal proportions of cane to the supply, and where these may be represented by plant, ratoon, and standover, both green and burnt, it will readily be appreciated just how far the practical difficulties are amplified. Such a hypothetical case would require the employment of thirty individual cane fibre values in C.C.S. calculations. In the terms of the Cane Prices Regulations, each of such varieties constitutes less than 25 per cent. of the total crop, and a weekly determination only is demanded. This means that over a period of a week, say—thirty-six stalks representative of each of the thirty classes must be stored, 1,080 stalks in all, and finally sub-sampled to provide the product of six completely fibrated stalks of each class and variety of cane. To apportion the work so that each of the five full days

of the week should receive its quota, the operator would be required to fibrate daily thirty-six full cane stalks, representing six classes and varieties. When it is considered that such a sample is even then not representative of the cane to which the figure as determined will be applied during the succeeding week, and bearing in mind the error introduced by the inevitable evaporation of moisture from the stalks during the usual storage, it must be agreed that more frequent sampling and analysis is desirable. Again one is limited entirely by the labour involved in the work.

Doubtless the complex case just discussed is extreme, and would not be encountered frequently in actual practice; but it is approximated to more or less closely in many of the mills in the southern districts of the State. In general, actual conditions would be intermediate in character to the hypothetical cases presented. For so-called "minor" varieties, a composite sample for all is taken weekly, from purely practical considerations, and I leave it to you as canegrowers to express your opinions on the grouping of such varieties as Badila and Uba, should they both be "minor" varieties at a particular mill. I would also request an alternative and practicable procedure which can be followed in these cases.

Finally, we must consider the desideratum of the individual canegrower, that the fibre figure as applied to his juice analysis for the calculation of his C.C.S., shall be that as determined on the actual cane he has supplied. Even in the most favourable circumstances of group harvesting and one cane variety only, no less than sixty fibre determinations would be required daily. To assure accuracy for the tests, about thirty-six stalks for each day's supply would be necessary, giving 2,160 stalks for all growers, which would be reduced by sub-sampling to a mere 360 full stalks to be completely fibrated in a working day, and analysed to give sixty individual fibre values. I refrain from calculating what the position would be where the number of daily suppliers is 300!

Gentlemen, I trust that this brief survey of the fibre problem will convince you that the Regulations at present operating for the determination of fibre in cane are a very fair and reasonable compromise, avoiding an impracticable method that would give results, each individually of the highest degree of accuracy, and providing one which can be operated successfully so as to give values which over a period are equally fair for all suppliers to the mill, as well as to grower and miller. Subdivision of the supply according to varieties and classes of cane is in itself sufficient to increase the labour involved in the work to the absolute limit, even though it is admitted that two growers supplying, say—Badila plant—are given an average fibre content of 10 per cent., whereas one supply may contain 11 per cent. and the other only 9 per cent. Evidence of this nature is at present before you.

I will therefore conclude by suggesting that the most one may hope is that the average fibre figure as obtained for the season shall be a true estimate of the actual fibre in cane. It is hoped to pursue investigations during the coming season on an expanded scale, in order that we may learn those weaknesses which lead to biassed results, or which give values grossly in error; and if possible, recommend amendments to the existing method which may assure the elimination of those errors. Beyond that, one is limited entirely by considerations of practicability.

Recent Advances in Cane Borer Investigations in North Queensland.*

By A. F. Bell.

SOME three years ago it became possible to give effect to the Bureau policy for the closer co-ordination of its plant protective services. With the impending retirement of the late Entomologist, and with the completion of the investigation of the more important insect problems of the south, Mr. Mungomery was transferred to Meringa so that his services and those of Mr. J. H. Buzacott could be concentrated on the important questions of grub and borer control. At the same time the cane breeding work was transferred from South Johnstone to Meringa, thus enabling closer co-operation between cane breeder and entomologists in the production and testing of new seedlings resistant to the attack of our two chief pests.

The first problem considered under the reorganised scheme was that of the effectiveness of the Tachinid fly as a controlling agent of the beetle borer. It had been felt for some time that the fly was much less efficient than was generally supposed. A system of extensive liberation of flies in areas where they were scarce was inaugurated and at the same time studies were made of the variation of naturally occuring fly populations. As a result of this work we have concluded that the Tachinid fly has at most only a very limited use in a few small areas in Queensland. In those areas where the fly was scarce this state of affairs was due to the unsuitability of climate and other conditions of the area and could not be corrected by fresh liberations of flies.

The Tachinid fly has achieved a satisfactory degree of control of the borer pest in Hawaii, but a careful comparison of conditions by Mr. Mungomery showed that those of Queensland were far less favourable and that duplication of this success could not be expected here. The three most important points of difference were:—(*A*) Queensland has a one-year cropping cycle, and during the critical period between harvest and the growth of the new crop the fly populations are decimated each year; the borer, being more hardy and being able, as we shall see later, to penetrate sheltered locations, survives in very much greater numbers. Hawaii, on the other hand, has a two-year cropping cycle, and hence there is always an abundance of well-grown one-year-old cane to harbour the fly and release large numbers to adjacent young crops. (*B*) The standard varieties at present being grown in Hawaii are much more resistant to borer than Badila and Clark's Seedling and, even in the absence of the fly, borer populations and damage would never be so great as in North Queensland. (*C*) Hawaii has 100 per cent. pre-harvest burning.

While it is true that in some districts a large proportion of borer grubs are parasitised towards the end of the season the damage has, unfortunately, been done by this time. The crux of the situation is that the borer gets off to a flying start, so to speak, and has done its damage before the parasite catches up with it. It might be suggested that this lag could be overcome by breeding vast numbers of parasites and liberating them early in the season; there are two factors which prevent this:—(1) it is impracticable to breed this parasite in great quantities and (2) conditions at that time do not favour the attack of the borer.

* Address to the Queensland Cane Growers' Conference, 23rd February, 1937.

(Also it might be mentioned that of the many cases where artificial breeding of parasites has been tried as a direct method of control not one has been a success.) In Fiji experience with the Tachinid fly has been similar to our own, and we are forced to conclude that under the conditions obtaining in North Queensland little help can be expected from this source.

Having cleared the air to this extent, last year we commenced a series of investigations along different channels. Although these are by no means completed they have yielded very interesting results which are given in some detail in a paper prepared by Mr. Mungomery for presentation to the 1937 Conference of the Queensland Society of Sugar Cane Technologists. These investigations have been carried out for convenience mainly in the South Johnstone district, but any findings are, of course, directly applicable to other areas. The following points of interest emerge as a result of the season's work:—

The number of borers which breed outside the canefields is negligible and they can be disregarded in considering control measures. On the other hand the free living beetle populations within canefields may be very great, and these are free to migrate to adjacent fields when such cane is harvested green.

The whole question of the survival of large numbers of borers, and thus their availability for the early infestation of young crops, is intimately bound up with methods of harvesting and field sanitation. For reasons which will become apparent later the mere selection of borer-free planting material probably will not have much apparent beneficial effect under present conditions. This precaution should be practised, however, and indeed other efforts will be largely nullified if it is not practised in conjunction with them. Selection of borer-free planting material is rendered necessary by the fact that borer larvæ or eggs within the sett are able to complete their development and emerge from the soil. There is, of course, also the question of the effect on germination. Care should be taken to see that the cut ends of setts are not exposed for any length of time, since borers are attracted to them, and soon commence to deposit their eggs at those surfaces. In connection with the cutting of plants attention is drawn to the fact that it is most undesirable, when selecting plants, to allow the discarded borer-infested portions to rot; they should be burned, as otherwise the borers contained therein will emerge.

When cane is cut green vast numbers of borers are not only left in the field clinging to the trash, or sheltered in tops and debris, but under suitable conditions of moisture they are enabled to breed in these crop residues. It is particularly noticeable that in the beginning of the season there is a strong tendency to cut the cane well back in order to discard immature cane and obtain a reasonably high C.C.S. content at the mill. The beetles left in the field immediately commence to lay their eggs in these freshly cut tops, and under suitable conditions of moisture the eggs can hatch out and ultimately give rise to mature beetles before the tops rot away.

Where conservation of crop residues is not practised this trash is burned, but it very frequently happens that in the first half of the season weather conditions prevent an early burn, and even then the burn may be quite incomplete. Naturally, the beetles which have not migrated to neighbouring fields and which are not well sheltered at the bottom of the trash blanket are destroyed, but the greater proportion of the eggs,

larvæ, pupæ, and borers within the cane tops and discarded canes are left unharmed. If, at this stage, the tops are raked into heaps and left to rot the leafless tops pack down tightly and remain moist and preserve ideal conditions for the survival and emergence of large numbers of borers. On the other hand, if the burnt tops are left undisturbed so that if weather conditions are suitable they dry out quickly, or if they are again burnt and properly destroyed, this large potential borer population is destroyed.

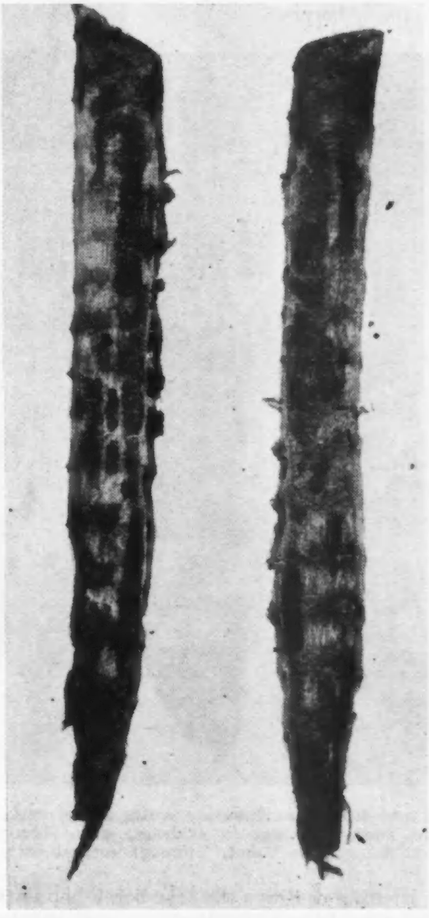


Fig. 42.—Section of cane top cut unduly long (11½ inches) showing tunnels of borer larvæ.

It will be noticed that emphasis is placed on the amount of stalk which is left when harvesting, and this is an important point in the matter of trash conservation. Although, of course, the conservation of trash permits the migration to adjacent fields of the free living borer

population left after harvesting, trash conservation *in itself* does not tend to increase borer attack unduly. Its importance lies in the extent to which it will protect the attached tops and discarded cane from drying out, and this, in turn, depends a great deal on the weather. The tangled leaves permit a good deal of aeration and very many less borers will mature than will be the case if the trash is burnt and the debris raked into heaps, when it dries very slowly and the rotting stalks prove very attractive to borers. It has also been found that unburned trash raked into every second row dries more rapidly still, and permits the survival and breeding of fewer borers.

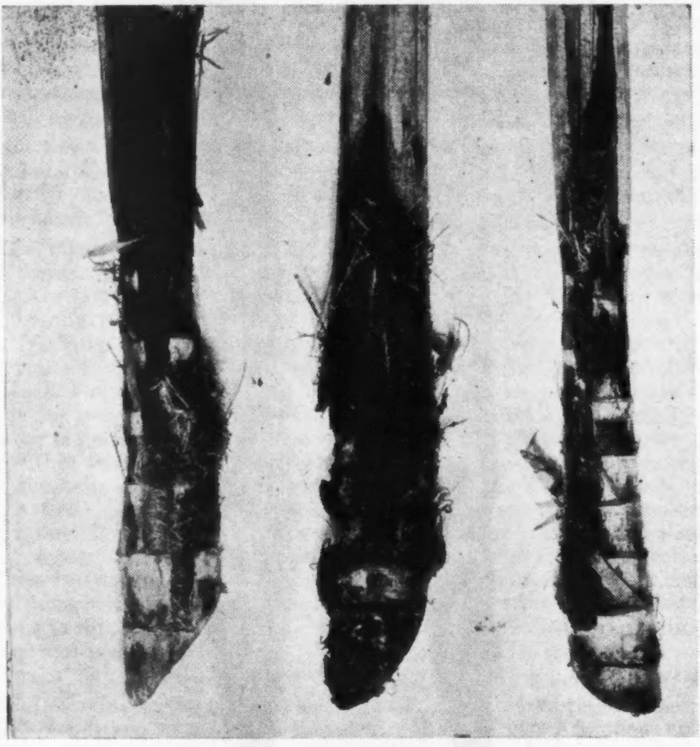


Fig. 43.—Showing cane tops taken from the centre of the trash row in a field of conserved trash. Cocoons in evidence, where borers have developed. Note that one eye has "shot," through contact with the moist soil.

Pre-harvest burning destroys the free borer population which otherwise can and does migrate to adjacent fields, and, moreover, portions of stalk attached to the burnt tops dry out more rapidly than would otherwise be the case, so that there is a negligible amount of breeding in this refuse. It would appear then that the only effective *immediately available* means of control is that of general pre-harvest burning, coupled with plant selection, for at least one season; it is obvious that the practice would have to be carried out uniformly and not just here and there. We are aware, of course, that many arguments may be advanced against

the practice of pre-harvest burning; that, however, does not in any way alter the dictum about immediately available effective measures of control, and it is for the industry to weigh the economic pros and cons.

Fig. 44.—Illustrating young ratoon shoots destroyed by borers invading them from the old stubble. The outside shoots (sectioned) show the borers in place.

It may be said that the Bureau is here speaking with two voices; that the agriculturists advocate conservation of trash while the entomologists advocate its destruction. There is really no conflict of advocacy. The agriculturists advocate, and quite rightly, the conservation of crop residues, as a general practice, to maintain the fertility of the land and/or to combat erosion. In a special circumstance the entomologist advocates the temporary destruction of crop residues to produce a desired result. Both practices will achieve certain economic results; the adoption of the one or the other must be decided on local circumstances.

It has long been known that resistance or susceptibility to borer attack is largely dependent upon the rind hardness of the cane involved. Experience has also shown that it is possible to breed canes with a much harder rind than Badila, and some advance has been made along these lines, as witness, for example, the increased borer resistance of the seedlings S.J.4 and Q.2 when compared with Badila and Clark's Seedling. We have recently had manufactured a small apparatus which enables the rind hardness of canes to be tested mechanically. The method of making these tests is described by Mr. Mungomery in the Quarterly Bulletin for October last year and in a paper by Mr. Buzacott which appears in the Proceedings of the 1937 Conference of the Queensland Society of Sugar Cane Technologists. With the aid of this apparatus it is intended to test the rind hardness of seedling canes in the early stages of their development, and so enable selection to be made on the basis of this very desirable quality.

It is possible that rind hardness of cane is appreciably affected by fertilizer and cultural practices, and this aspect of the problem is being kept in mind. Most growers will have observed that, at least in more or less normal borer years, borer damage is concentrated in the butt of the stalk. This suggests that the tendency for the trash to cling about the base of the stalk makes the rind softer and permits easier entry for the borer. This question is being studied by a series of trashing experiments, it being expected that early trashing will rapidly harden the rind of the butt. These trials are being costed as they proceed and thus the economic value of the results, if any, can readily be assessed.

In the face of the present vast numbers of borers, trapping can have no value. Due to the fact that the borers are strongly attracted by souring cane it has been suggested at various times that lures might be used to attract beetles at the time of the year when their numbers are at their lowest. This point has been kept in mind, and from time to time tests have been made with a large number of possible lures but without successful results.

We believe that the borer problem will ultimately be solved by the substitution of resistant varieties. Naturally, one cannot forecast when this will take place, for Badila is in many respects a difficult variety to replace, but inevitably its sands of time are running out.

Cane Grubs in Southern Queensland.

By R. W. Mungomery.

In Southern Queensland "white grubs" have caused sporadic damage to cane crops over a long period of years, and their worst effects have been felt in the Isis, Gin Gin, and Bundaberg districts, where the red volcanic and forest loam soils often support large infestations. The extent and intensity of their attacks have varied greatly in different periods, and the reasons for these variations appear to be intimately connected with weather conditions and certain factors dependent on the behaviour of different cane varieties.

Extremes in weather may not only influence the pest directly by killing off large numbers, but they may also influence it indirectly by affecting the parasites and predators which in turn prey upon the grubs and beetles. In the past, too, cane varieties have been responsible for

great fluctuations in the pest and the varietal problem may prove of even greater importance in the future, unless measures are taken to counteract in some way the additional opportunities given to the pest to increase under a lengthened cropping cycle.

It is a well established fact that certain cane varieties possess a vigorous rooting system and this ability to replace quickly their damaged roots often enables them to recover from the effects of a moderate number of grubs. No variety, however, will continue to stand up to large grub infestations and still produce a good crop. Probably the greatest influence of different varieties on the cane grub problem centres around the length of time required by these varieties to produce their most profitable crops, and also on the number of years these particular varieties can be successfully ratooned.

It was noticed that on some estates, where formerly Badila was grown extensively as a two-year crop under unirrigated conditions, grub damage increased considerably and grub populations remained at a consistently high peak. In this instance, by allowing the crops to run to second ratoons, a period of six years was involved. When grubs were, in this way, left practically undisturbed over this period they built up into enormous populations, so that the resulting beetles, on emerging, soon overflowed into the adjacent fields and increased the infested area.

When gumming disease was of major importance in South Queensland, and every effort was being made to get rid of the disease, one of the elimination varieties was Q.813. This variety, by reason of its extreme sensitiveness to grubs, soon showed up the smallest degree of infestation. It matured in a year, but it was a light cropper and it was not usually carried beyond the second ratoon crop before being ploughed out. Similarly, some of the gumming-susceptible varieties, such as D.1135 and M.1900 Seedling, also produced fairly light crops, and these had to be ploughed out and replanted fairly frequently. Under these conditions the grub population was continually being harassed, and very little opportunity (except in isolated cases) was given the pest to build up large numbers.

With the almost complete replacement of the gumming-susceptible varieties by some of the resistant P.O.J. and Co. varieties, we now find that many growers are allowing their crops to stand over or ratoon for longer periods, thus lengthening the period between plough-outs, and consequently we are fast approaching the state of affairs which existed when standover crops of Badila were grown on certain plantations. That is to say, farming conditions are becoming more favourable for a rapid increase in the grub and beetle pest, and damage to cane crops is likely to become more severe.

Habits of the Pest.

In the Isis, Gin Gin, and Bundaberg districts three different serious grub pests exist, but, except that they occur in different soil types, they might be considered almost identical in habit. The following brief description of their cycle, therefore, is equally applicable to any one of the three species, and it will serve to clarify some of the recommendations given for the control of the pest. The life cycle of the pest is of two years' duration, and the bettles which are responsible for the pest usually emerge in November or December, after a period of soaking rains. The eggs are laid deep in the soil, where they hatch into tiny grubs after a lapse of about a fortnight. The grubs live at first by ingesting

the organic matter present in the soil, but later on they attack the roots of living plants. There are three different grub stages, the first two together occupying about nine months, and they pass from one stage to another by a series of moults. In September they change to the third stage, and it is not until this final grub stage is reached that any noticeable damage occurs to the cane crops. At this period, however, they feed very voraciously, and by November, December, or January (depending largely on weather conditions) yellowish grub-eaten patches of cane beçome noticeable. By the following March the grubs are usually full fed, and they gradually retire deeper into the soil, eventually to pupate and transform into the beetle stage to commence the cycle anew.

Methods for Control.

As pointed out previously, standover crops and a large number of ratoons give the pest every opportunity for increasing, and consequently, when planting a new field, it is most important to make sure that it is absolutely clean. Fields which carry large initial grub populations are doomed to failure. It is unwise to ratoon a block once grub patches become numerous and extensive. All ploughing operations should be carried out in the summer months when the soil is moist, and when the majority of the grubs are located in the top layer of soil, so that the plough will kill many and expose others to be eaten by birds. The use of a specially constructed rotary hoe is particularly recommended for killing large numbers of grubs, but where such a machine is not available hand picking should still be carried out when ploughing. Fields should not be ploughed out and replanted immediately afterwards, as this imposes too small a check on the grub populations.

Should any small centres of grub infestation occur in the young cane crops they should be fumigated. This will have the effect of preventing in future years the occurrence of even larger grubby patches, which assuredly must develop if these small centres of infestation are neglected. This pest is very costly to deal with when infestations are heavy, and for that reason we stress that every effort should be made to prevent the pest increasing unduly. A small expenditure directed towards keeping the pest well controlled will undoubtedly save a much greater expenditure in future years if the pest is temporarily ignored and allowed to increase.

Finally, we have not overlooked the question of some biological aid in suppressing the pest, and to that end we are now stocking up these areas with toadlets of the Giant American Toad. If conditions prove suitable for their breeding and attaining large numbers they will, we hope, exercise some permanent benefit in reducing the bettle and grub pest in the areas now infested.

Mule Breeding at Bundaberg.

By N. J. King.

SOME eighteen months ago three jack donkeys were selected in the United States of America, for the purpose of attempting to breed good type mules for work in the Queensland canefields. Two of these animals were purchased by the Fairymead Sugar Co. Ltd., while the third animal was taken to the Burdekin area.

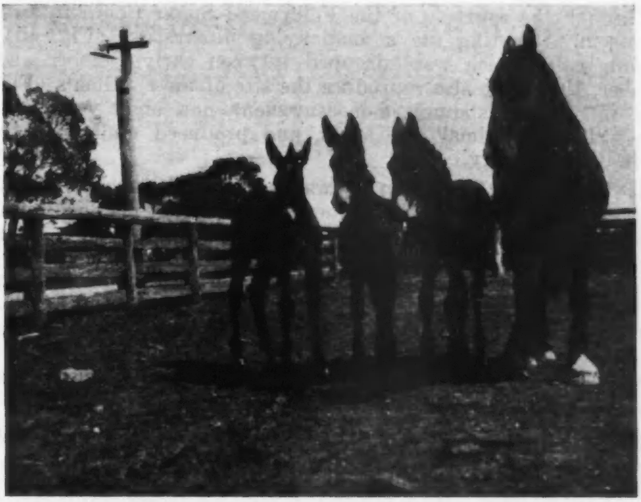


FIG. 45.—A group of mule colts, 3-5 months old, sired by the jack pictured in Fig. 46.

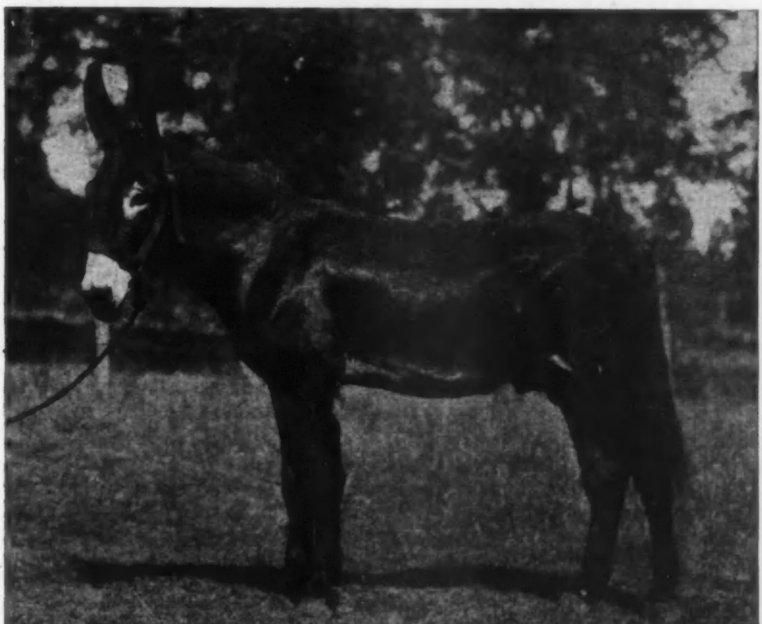


FIG. 46.—The sire of the colts pictured in Fig. 45. This jack is eight years old and stands 15.1 hands.

Through the courtesy of the Fairymead Sugar Company, we have pleasure in presenting the accompanying illustration (Fig. 45) of a few mule colts which were dropped between early October and late December, 1936. We also reproduce the sire of these animals (Fig. 46), a jack of 15.1 hands standard measurement, now eight years old. He was a well-tried animal in Kansas, and produced mules of excellent type in that country.

At Fairymead Plantation he was mated with 16-hand Clydesdale mares, and to date he has produced 11 foals. The height of the youngsters compares favourably with that of Clydesdale foals of the same age, while their weight is also practically identical. They have been fed uniformly with the usual foals on the plantation, and no variation in treatment has been introduced to date. The outstanding characteristics of the mule colts are their playfulness and inquisitiveness.

It is intended that they be handled and broken in to work as two-year-olds, and put to farm work at the age of three years.

Growers will doubtless be pleased to learn of the early success of this experiment, and will await further results with interest. As only one class of mare has been used for breeding—an attractive type of farm animal—it is not possible to suggest whether the mule type would vary with variation in the type of dam.

Experiment Station Field Days.

The Field Days, conducted in former years by the Bureau, were functions keenly anticipated by canegrowers in neighbouring districts, and we are pleased to report that circumstances are such as to warrant the re-institution of these gatherings. The reorganisation of our field stations, and their development in recent times, should provide much of interest to growers attending Field Days in the future.

The scheme will be initiated with the Field Day to be held at the Bundaberg Station in June next. It will be held at the time the Advisory Board conducts its midyear meeting. It is felt that a half-day is sufficient for the purpose, and for the convenience of growers, the function will be held in the afternoon. Full detailed particulars of this and the similar gatherings at Mackay and Meringa, to be held later in the season, will be made available in due course.

H.W.K.

Bound Copies of the Quarterly Bulletin.

As this Bulletin completes the fourth year of issue of the Cane Growers' Quarterly series, it is proposed to have a limited number of copies of Volumes III. and IV. combined and bound in a cloth cover. Any canegrower or organisation desirous of obtaining such a copy is requested to forward an application, accompanied by the nominal sum of 2s. 6d., to the Director of Sugar Experiment Stations, or to do so through the Secretary of branch organisations. It should be understood that the number of volumes available is distinctly limited, and applications, which will be dealt with in the order of their receipt, must be in the hands of the Director before the 30th June next.

H.W.K.

Gumming Disease in the Mulgrave Mill District.

By ARTHUR F. BELL.

History.

EARLY in 1925 Mr. W. Cottrell-Dormer, who was then attached to the staff of the Bureau of Sugar Experiment Stations, reported the occurrence of an outbreak of gumming disease in the Aloomba area. The disease was found on six farms, in fields totalling 170 acres. The varieties found to be most severely affected were Clark's Seedling, H.109, E.K.1, E.K.2, E.K.28, Pompey, M.Q.1, and the Gorus, death of plants being particularly noticeable in Clark's Seedling and H.109. Enquiries showed that the disease had certainly been present in 1921, and some evidence was available to suggest that it had been introduced into the district by means of diseased cane plants brought there from the Herbert River.

The presence of the disease and its characteristics were given due publicity. A voluntary quarantine was proposed, to embrace the area bounded by the Mulgrave River, Behana Creek, and the North Coast Railway, and farmers were urged to grow resistant varieties, particularly Badila, B.147, and Q.813. The outbreak was gradually brought under control, and at the time of the writer's return to Queensland in 1928 the field staff reported the area to be apparently disease free.

In September, 1934, a fresh outbreak was discovered in the same area and a survey of the district revealed the presence of the disease on eleven farms. Whether this new outbreak was due to the re-introduction of the disease by illicit importation of cane from prohibited districts, or whether it was due to the disease having been carried over from 1927 in odd stools of a susceptible variety, could not be ascertained. Certainly, under the conditions of the voluntary quarantine set up in 1925, susceptible varieties had not been entirely eliminated from the quarantine area, and it is possible that the planting of odd stools, as supplies, of susceptible cane in fields of resistant varieties may have permitted the disease to persist unnoticed.

This second outbreak had particular significance inasmuch as the variety S.J.4 had by this time assumed the position of the major commercial cane in this area while it had been proved to be the variety most susceptible to gumming disease ever tested by us; in addition, the variety Clark's Seedling had re-assumed its place in the commercial plantings. It was obvious that the control of this outbreak would present much more difficulty than did the previous one.

On April 6, 1935, a Proclamation was issued under the Diseases in Plants Act, defining the boundaries of a quarantine area in which the planting of the two varieties, S.J.4 and Clark's Seedling, was prohibited, while the removal of cane from this area, except for the purpose of milling, was also prohibited. The season 1935 was not characterized by a long or intense wet season and the disease did not appear to spread to any great extent, although its presence on another farm in the Highleigh area necessitated an extension of the quarantine area. Concurrently a survey was made on 25 per cent. of the farms in other parts of the mill area, but no other centre of infection was found.

The seasonal conditions ruling in 1936 were such as to favour greatly the spread of gumming disease, and recent surveys indicate that the disease has spread to an alarming extent and has passed beyond the boundaries of the prescribed quarantine area. It was definitely found on twenty-four farms, and its presence is suspected on four others. By reference to the accompanying map (Fig. 47) it will be seen that the spread of the disease has been mainly in a north-westerly direction into the Highleigh district, infection having been carried forward by the prevailing south to south-east winds. A total of forty-five fields, comprising some 450 acres, are known to be, or suspected of being, diseased. The varieties chiefly involved are S.J.4 and Clark's Seedling, but the disease has been found in several other varieties, including Badila, when grown closely adjacent to badly diseased S.J.4.

Description of the Disease.

Gumming disease is one of the oldest known diseases of sugar cane; it has been present in Australia for many years, and has been responsible for at least two disastrous epiphytotics in Southern Queensland. The last outbreak became widespread in the Bundaberg area in 1924, and reached its peak in 1929; during this period the unit yields of cane declined by some 25 per cent.; since a continuous substitution of resistant varieties was taking place it is obvious that the reduction of yield in the susceptible varieties was considerably greater than this. At the present time, thanks to the wholesale planting of improved resistant varieties, gumming disease has been practically eliminated from the Bundaberg district, while acre-yields are considerably in excess of those obtaining prior to 1924.

Gumming disease is caused by a small rod shaped bacterium, *B. vascularum.* The outstanding characteristic of the disease is the production of a yellowish slimy gummy fluid which oozes from the cut ends of badly diseased canes and which consists in the main of myriads of the causal bacteria. Such oozing may be commonly and conveniently observed in cane on trucks. Primarily, however, gumming is a leaf disease, and gum may be sweated from the stalks in its later stages and in the case of susceptible varieties. For the purposes of field surveys the symptoms most commonly used for diagnosis are the characteristic yellowish leaf streaks. These streaks follow the course of the veins of the leaf and so run straight and at a slight angle to the midrib. They are generally uniform in width, which ranges from $\frac{1}{8}$ to $\frac{1}{4}$ inch. Streaks may arise anywhere in the leaf blade, but the majority arise near the margins and towards the tips of the leaves; the length may vary from a couple of inches to upwards of half the length of the leaf. The colour of streaks is yellow to yellowish brown, usually dotted with large numbers of reddish dots. As the streaks become older the tissue within the boundaries of the streak dies and becomes ashy coloured, the dead area gradually extending longitudinally until it extends throughout the length of the streak. Streaks are best found following periods of wet windy weather, and may be very difficult to find during long dry spells.

In the case of resistant varieties the infection remains confined to the leaves, but as soon as susceptible varieties suffer a check in growth, the bacteria pass down the leaf and into the stem where they attack the stem tissues and cause the formation of the so-called "gum"; in a proportion of the canes the growing point is attacked and destroyed, and the cane dies.

Ratoons from diseased crops may often come away very weakly, and the production of chlorotic or whitish leaves is a common symptom; generally speaking, however, ratoons are less susceptible than plant cane. Setts from badly diseased canes germinate but poorly, and often give rise to whitish sickly plants, which die out or are backward for a considerable period.

The effects of the disease are intensified by the presence of unfavourable conditions which impose growth checks. Thus the disease is always much worse in localities where the drainage is poor or where the moisture holding capacity of the soil is low.

Gumming disease may be transmitted by the planting of diseased setts, the cutting of plants with an infected knife or, most commonly, from leaf to leaf during periods of wet windy weather. The wind causes the leaves to lacerate each other by means of their small sharp marginal spines. The bacteria are enabled to ooze out of such wounds on to the surface of a leaf and from there are carried in the driving and splashing raindrops to similar wounds in leaves of healthy canes; they then enter the leaves through these wounds and set up a new infection.

Control.

It is difficult to over-estimate the seriousness of this disease which is an important factor not only in the field but also in the mill, where it may greatly impede boiling. It is true that, varieties being the same, the effects of the disease are more pronounced in the southern part of the State than in the northern section. On the other hand, however, it was clearly shown in the 1925 outbreak that Clark's Seedling and H.109 were too susceptible to be grown in the presence of this disease under North Queensland conditions. Still more so is this the case with S.J.4, which is considerably more susceptible than even Clark's Seedling and H.109.

The variety S.J.4 is particularly well adapted for growth on the second-class soils of North Queensland and in the three northernmost areas it is computed that there are some 8,000 acres planted to this variety. It would be a matter for extreme regret if the variety had to be abandoned over this large area on account of the presence of gumming. There are, therefore, two phases of control to be undertaken:—(1) the restriction of the further spread of the disease, and (2) its elimination by the planting of resistant varieties.

In order to assist in restricting the further spread it is essential that every effort be made to ensure that the conditions of the quarantine shall be strictly observed in the area which will be proclaimed shortly. To this end the Proclamation provides that there shall be no planting of certain susceptible canes such as S.J.4 and Clark's Seedling (including this cane grown under its alternative names of P.Q.1, Benbow and Gaspari), and that no cane shall be taken out of the area except for milling purposes. Farmers should avoid the quarantine area as they would the plague when a supply of planting material is under consideration. Where suitable, the resistant varieties Badila, Q.813 and B.147 should be grown and, in addition, we would recommend that immediate trial plantings be made of P.O.J.2878, Korpi, and Q.1098.

The gumming disease problem of Southern Queensland has been very satisfactorily solved by means of the substitution of disease resistant varieties collected and tested by the Bureau, and it is proposed to work

along similar lines in this district. During the current season observational plantings will be made in the quarantine area with all gumming resistant varieties available, both imported canes and our own seedlings. It is confidently expected that suitable canes will be found before very long, but in the meantime full use should be made of existing available resistant varieties.

A further consideration of the map reproduced in Fig. 47 should convince anyone of the inevitability of further spread if no check is interposed, and it is obvious from the direction of spread under natural conditions that large areas of Mulgrave and Hambledon are directly and immediately menaced.

Sugar Experiment Stations Advisory Board.

The Board, under the Chairmanship of the Hon. F. W. Bulcock, M.L.A., Minister for Agriculture, held its first meeting for 1937, at the Department of Agriculture, Brisbane, on the 26th February, when a number of matters of importance were dealt with. It was decided that rat studies be continued by the entomologist at Mackay, when attempts will be made to study the life history of the rat, field populations, and the relative efficiency of various baits. A full discussion took place of ways and means of controlling diseases through the agency of approved varieties, and the Board will give further consideration to the more efficient control along these lines at the June meeting. This meeting will be held at Bundaberg, in conjunction with the first farmers' field day held at the Station for eight years. It was agreed that the fibre investigations instituted last year in North Queensland, be extended to the Central and Southern districts.

Consideration was also given to the possibilities of alternative crops for canegrowers, and the Minister intimated that he would keep members informed of developments in this regard, following his forthcoming visit to North Queensland.

Keen regret was expressed for the circumstances necessitating the retirement of Mr. A. P. Gibson, who has given many years of service to the Bureau, and who has been stationed in the Burdekin district for the past seven years. When the consequential vacancy is filled, attention will be paid to the request for field assistance in the Innisfail district.

In view of the favourable state of the finances, so far as the Experiment Stations Trust Funds are concerned, members expressed the hope that the levy for the 1937-38 season might be reduced to ¾d. per ton, as against 1d. for the previous year. This matter will be finalised when it is possible to forecast the probable cane yield for the coming crop.

H.W.K.

David Whyte, Government Printer, Brisbane.

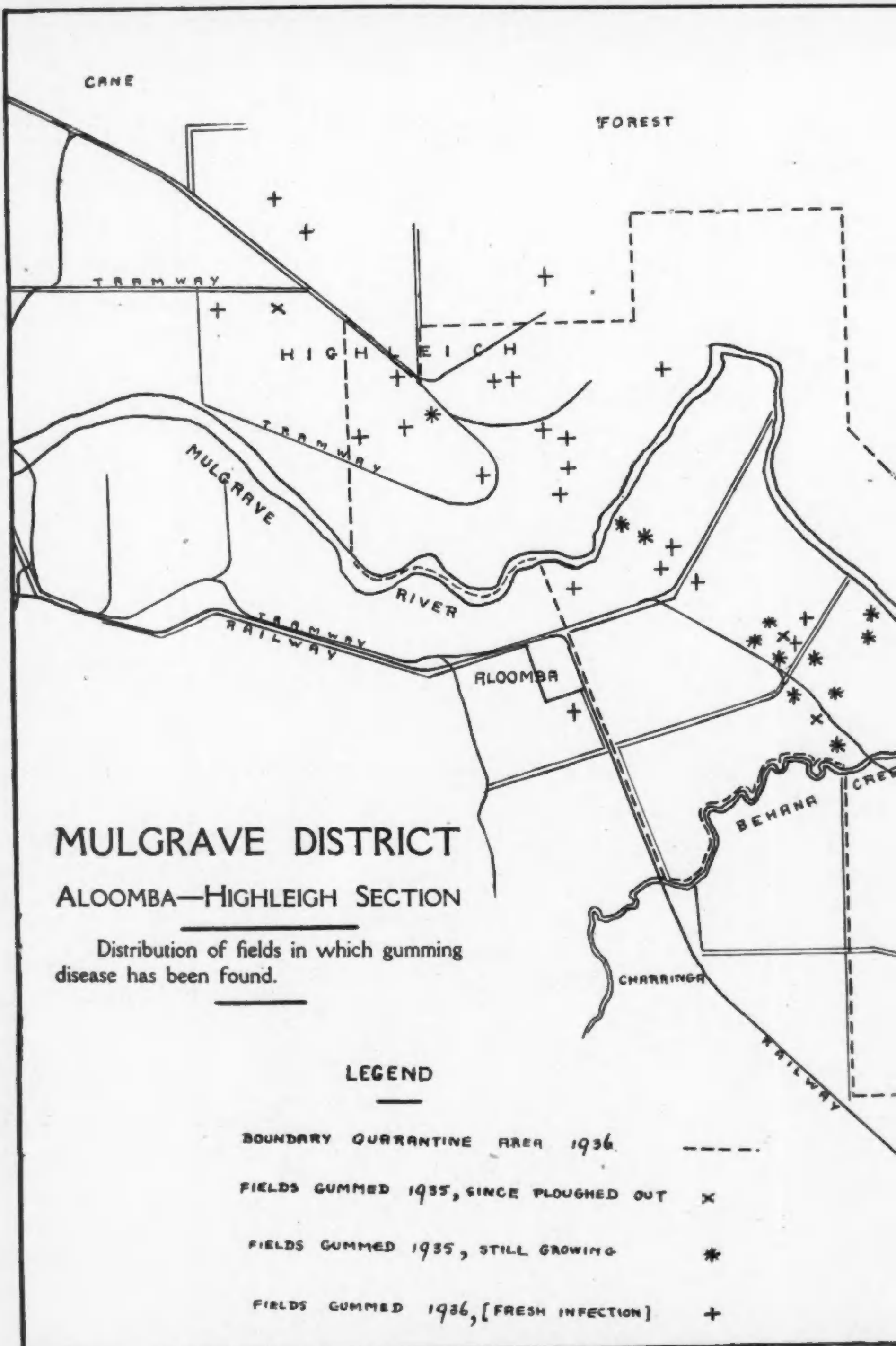
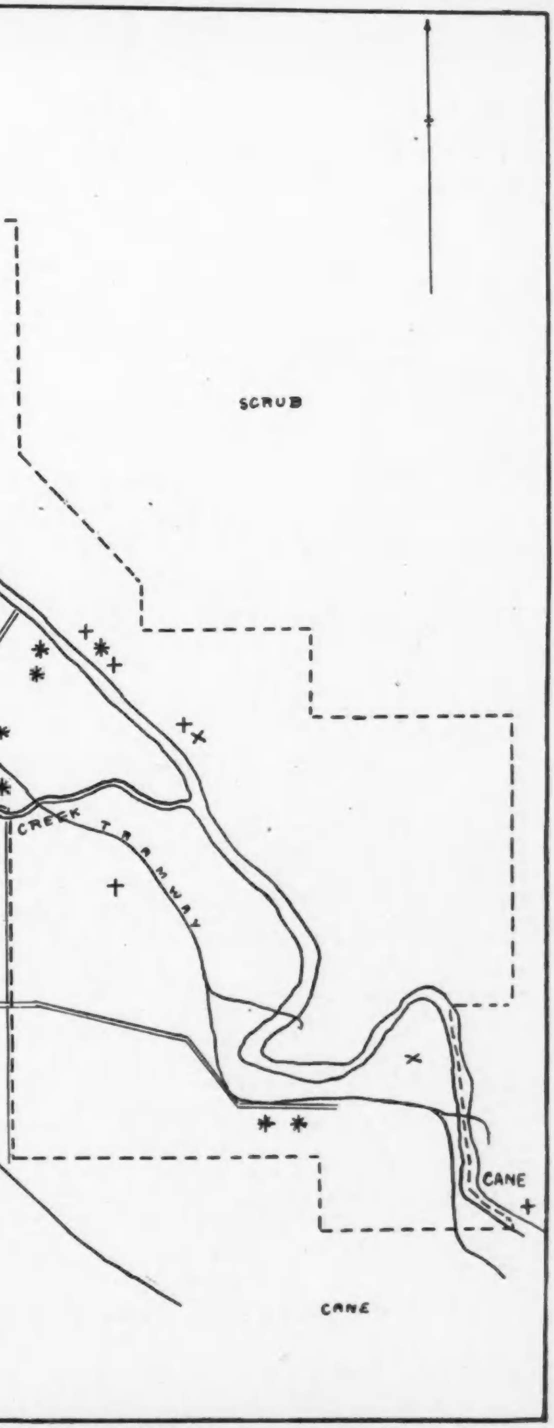


Fig. 47.—Sketch map of Aloomba—Highleigh Section, Mulgrave Area, showing original i
spread. It is apparent that the disease is spreading in a general north-westerly direction under th



inal infected fields and those to which disease has since
der the influence of the prevailing wind.